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View at the Montebello Filters, Baltimore, Md.

Laboratory Research in Water Purification Control

Coordination of Laboratory Research to Plant Operation and Practice: Resume of the Work Accomplished at One Large Filtration Plant

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IN modern practice the application to industry of research has a value beyond realization. This value is being utilized in commercial fields; in fact is the foundation of many industries, but what of the average water plant? Are water plant operators generally aware of the advance in purification methods and processes and of the research that has made this possible? Observation indicates that even with efficient journals many have but slight knowledge of these newer "tools." It is realized that with the trend of the times, efforts are being made to disseminate this information through the medium of "short sanitation schools" and state or local associations. The stimulation of such contacts is extremely valuable and serves as adjuncts to the usual periodicals. In many instances the problem is not merely the presentation of new pertinent facts to the operators, but the necessity of educating those in financial control as well.

The Responsibility of Larger Plants.—Due to the lack of this "educated money" the task of developing new phases and methods of control rests upon the larger plants. These organizations have sufficient trained personnel to carry forward this work for the benefit of all. That such organizations have accepted the responsibility is shown by reviewing current technical literature.

A resumé of the service rendered by one organization and the practical results obtained from it appears to be of interest. When considering the work presented, it must be remembered that the results were obtained in odd hours and in no way detracted from the main task of the personnel; namely, supervision of operation of routine laboratory control. A survey of the records for the past ten years discloses many phases and types of problems studied. The initial task was to control the growths of micro-organisms and bacteria in the sand filter beds by chlorine sterilization.

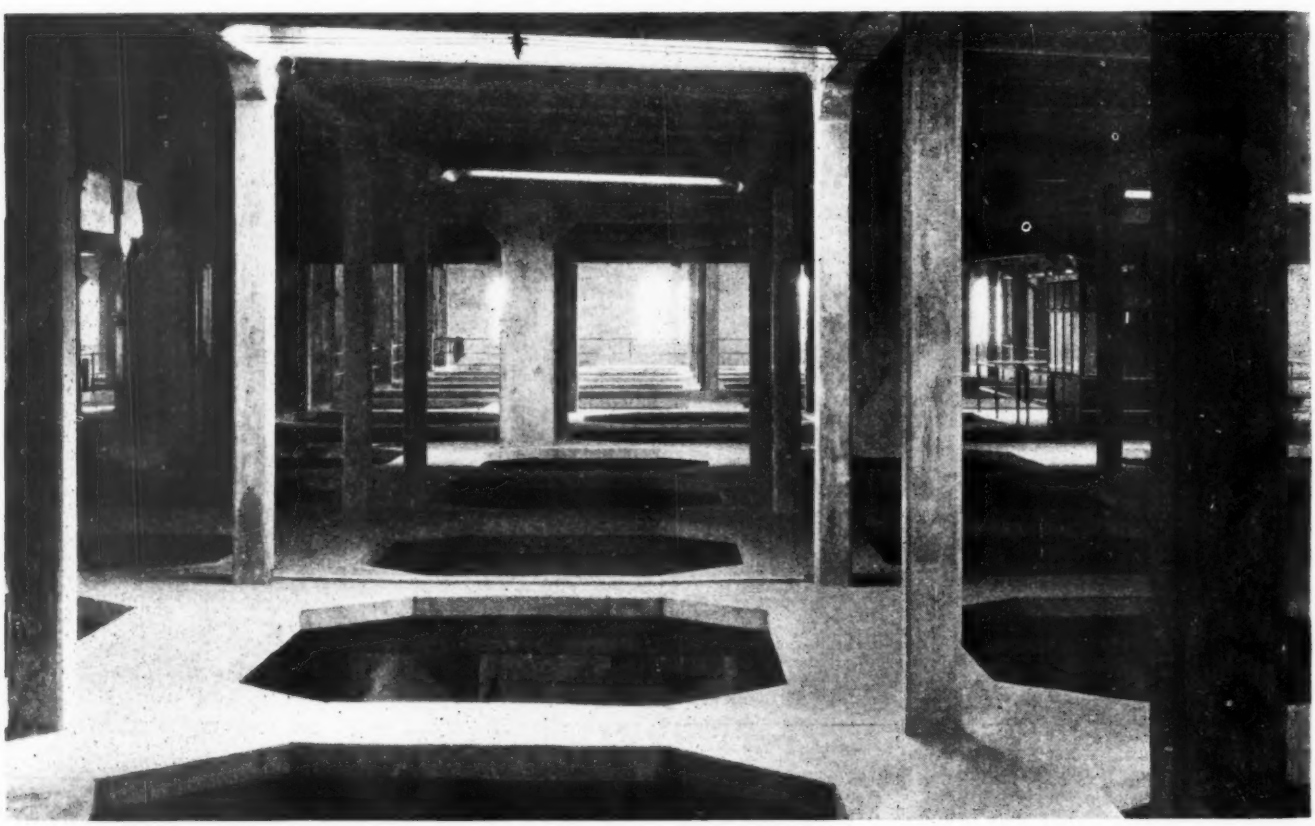
Corrosion of Metals by Water.—Extensive work was undertaken on the corrosion of metals by water. This effort was in keeping with modern thought on the subject; the final chapter of the study has not yet been written, if it ever will be. Results were obtained in about 1922 which showed clearly that the hydrogen-ion concentration of the water was a controlling factor in preventing deterioration of iron mains. Also that the hydrogen-ion concentration for proper coagulation of water, using alum, produced cold water corrosion of the pipes. "Red Water" elimination by the use of lime to give an alkaline water pH value about 8.0, is so common in this day that it seems superfluous to call attention to the pioneer work of an earlier date. The utilization of this information led to other investigations. A series of experiments were undertaken to devise a "fool proof" oxygen electrode for use with a recording potentiometer. The tungsten electrode was developed to measure the alkalinity (pH) of the water, thereby controlling the lime application. This assured the elimination of "red water troubles" in cold water devoid of the factor of excessive alkalinity. Precipitation of calcium carbonate from the water at pH values about 8.0 gave a non-corrosive surface. Establishment of the "calcium carbonate curve" controlled the formation of this protective coating by regulating the relation between pH value and precipitation. Other corrosion studies have shown the mechanism of pipe pitting and demonstrated clearly the formation of acidic tubercles. The resistant value to corrosion of zinc, copper, and lead were also investigated.

Studies Affecting Design of Mixing Basins.—The physical-chemical characteristics of alum floc was another investigation extending over a period of years (1922-1931). The data obtained is of value in determining the efficiency and design of mixing basins. The study included a comparison of plant and laboratory relationship of the chemical composition, settling phenomena and of the structural formation as revealed by the microscope. The pH (5.5) value of maximum alum floc formation and of re-solution (8.4) were obtained. Another phase considered was the relative value of velocity and time of agitation in a mixing basin upon a plant basis. This was a preliminary report without definite conclusions. It is expected that with the completion of this work in the near future, a definite value between velocity and time of mix will be established.

Similar characteristics of the floc produced by iron and lime were studied. It was found that the iso-electric point of floculation of ferric hydroxide so formed was in the alkaline range (pH 9.4). The precipitate did not redissolve at higher alkalinities (pH 14.0). The selective colloidal adsorption of manganous hydroxide at pH values of 9.4+ by this material was also noted. These studies gave a practical method for removing troublesome manganese compounds from the supply. Continuing the work on iron salts an investigation was made of the characteristics of the floc produced by "chlorinated copperas." This floc was found to be a practical coagulant in acid waters (pH 3.5) as well as for the usual alkaline waters. This pre-oxidized material was an excellent color adsorbent. The chemical composition of the floc was similar to that produced by other iron salts.

The effect of manganese upon the standard ortho tolidine color test for residual chlorine was investigated. This work showed that hydrated oxides of this metal produced oxidation of the indicator in direct proportion to their concentration. Practically applied, it demonstrated the unreliability of residual chlorine tests, as a criterion of water sterilization, when manganese is known to be present in the supply.

Turbidity Measurement for Filtered Water.—Studies of floc formation led to the consideration of a turbidity



Interior View at the Montebello Filters of the City of Baltimore, Md.

measurement for filtered water. In 1922 a device was developed to assure the delivery of clear water by each filter unit. This apparatus, based upon the principle of the Tyndall beam is very sensitive to small concentrations of suspended material. The turbidimeter is in daily use and filters are washed when it indicates a turbid effluent. A modification of this instrument was developed for laboratory control, using standards based upon suspended colloidal material as determined by the Jackson Candle Turbidimeter. This detector (Baylis Turbidimeter) is sensitive to 0.1 part per million.

Mud Deposits in Filter Beds.—Another interesting phase was the question of mud deposits in sand filter beds. Preliminary studies indicated that cracks and ridges are due to the compacting of the sand grains caused by the adherence of their gelatinous coatings. Washing with excess velocity of water or with lateral sprays were found to be effective in reducing or eliminating this trouble. A very practical paper, recently published, presented data showing the velocities of wash water necessary to assure good washing of the beds. The information obtained indicated that velocities in excess of two feet vertical rise per minute are needed to keep the beds clean. This study was later confirmed by the work of Hulbert and Herring of Detroit. Discussion of the proper sand size for such beds has been published. A top layer of 0.5 millimeter in diameter is believed to be the best for general use.

New Unit for Measurement of Micro-Organisms.—An interesting study was conducted upon micro-organisms, noting characteristic types. This resulted in the suggestion of a new unit for measurement. A cube 10 microns in diameter or a cylinder 10x100 microns being taken as the standard. This is more correct than the present standard which considers square microns as the basis. It is obvious that cubic content gives a better picture of the volume of organisms present than does the measurement of a plane surface.

Contrary to accepted opinion, it was shown that if sufficient carbon dioxide were present, very cold water had little or no effect upon the life of spawn and young fish (trout and perch). The work demonstrated that fish would not live in alkaline water (pH 8.0+) at a low temperature (4°C) containing excessive oxygen. If, however, free carbon dioxide were present these conditions did not impair life functions. The information contained in this study has been of value in refuting complaints that the water killed gold fish when kept as household pets.

Permanent Color Standards for Iron Determination.—It has been realized for some time that the permanent color standards for iron determination could not be made as directed in "Standard Methods." An investigation disclosed the source of these errors, publication of which served as a warning to those similarly troubled. Sampling of water from the bottom of the river became necessary. A device was developed making this possible at any depth of water from the floor of a spanning bridge situated at any reasonable height (50-70) feet above the surface. This apparatus made possible the study of conditions on the river bottom with a minimum of effort in sampling.

B. Coli Content of Tap Samples.—A final interesting study showed the effect of open reservoirs on the B. Coli content of tap samples. Under conditions of excessive pumpage with violent fluctuations of the reservoirs, organisms were obtained at intervals in the tap samples although water in the general system not passing through them was sterile. Secondary chlorination of the basins is practiced to eliminate this condition. The evidence showed this condition to be of no sanitary importance in relation to pollution.

The studies presented in this paper were not the work of any individual. During this ten year period there have been many changes of personnel. Personal credit is not sought by the author, nor has proper acknowledgment been made to others whose work has been reviewed. The paper is a presentation of the coordination of laboratory research to plant operation and practice. Its object is to encourage others possessing the facilities to "go and do likewise."

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Institutional Sewage Treatment Plants in Ohio

Records of the Ohio Department of Health show that there are 890 individual sewage treatment plants in Ohio serving public buildings and places and accessible to city or county sanitary sewerage systems. The Ohio Health News lists these plants as follows:

Institutions—(including all except State Institutions)	103
Schools—(Public, Private and Parochial)	644
Country Clubs, Camps, Parks, Resorts, etc.	81
Other Places	62

At most of these places a careful study of local conditions was made by the engineer or architect in charge and the Department of Health to determine the most suitable and profitable type of sewage treatment and the plans were prepared accordingly and approved by the department. The various types of plants that have been installed are listed below:

Plain Settling Tank with outlet direct to receiving stream	414
Settling Tank and Leaching Device or Leaching Device alone	162
Settling Tank and Lath Filter system	95
Settling Tank and Stone Trickling Filter system	3
Settling Tank and Surface Sand or Cinder Filter Beds or Filter Beds alone	165
Settling Tank and Sub-Surface Sand or Cinder Beds	50
Settling Tank, Lath Filters and Sand Filters	1

Although careful study was given to the design of these plants, little attention has been given heretofore to their operation and maintenance. During the past year, however, the engineering division of the Department of Health inspected 230 of the above-listed sewage treatment plants, most of the inspections covering those plants having secondary treatment devices, such as lath or sand filter beds. Some of the plants were found to be surprisingly well operated and maintained, others were found to be in deplorable condition and were effecting very little, if any, treatment of the sewage. In a few instances the caretaker of the building was surprised to learn that there was a sewage treatment plant on the grounds.

Many of the boards or other officials in charge seem of the opinion that a sewage treatment plant will operate indefinitely without any attention whatsoever. The result is that these plants, which cost several thousand dollars to construct, have to be entirely rebuilt after a comparatively few years of use. This is an unnecessary expense as well as being a nuisance and health menace to the entire neighborhood in the meantime. In most cases a little common sense and a few minutes each week spent in operating the plant would have saved all the expense and trouble.

The department plans to continue the inspection of as many of these plants as possible each year with the hope of obtaining better operation and plant results in the future.

Methods and Cost of Constructing Corrugated Iron Pipe Storm Sewers

How Drainage System of Whitehaven Memorial Park, Rochester, New York, Was Designed to Meet Varied Conditions

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A RATHER novel form of storm sewer construction was employed in the development of Whitehaven Memorial Park, Rochester, N. Y., in following the policy of varying design to meet special conditions of service and installation.

The Whitehaven Memorial Park is a park-plan cemetery located about 8 miles east of the city of Rochester. It is being developed by a group of Rochester business men to serve the needs of that city and several adjacent villages. The tract being developed is about ½ mile wide, measured north and south, and one mile long, east and west, with an area of approximately 340 acres. During the past summer, 60 acres of this tract have been laid out into burial lots, and storm sewers and water lines installed and roadways built.

Almost bisecting the property is Irondequoit Creek, which flows north and south through a valley from 200 to 300 ft. wide with sides sloping gently up to the land on either side. The bed of this creek is some 30 to 40 ft. lower than the level of the land on either side which is to be developed into burial sections.

As in every development of this kind, a drainage system forms an important item of design and construction. In the case of Whitehaven Memorial Park, the drainage system includes the enclosure of a small stream which formerly crossed the northwest corner of the tract, provisions for the drainage of driveways and drains for the underground sprinkling system.

Design Features.—In designing a storm sewer system that would meet the above needs, an attempt was made to adapt the design to meet the varied conditions imposed upon different parts of the system. Of much help in this direction were the results of previous excavation which gave a fair knowledge of the undersoil conditions as they existed. From this, it was known that about 9 ft. below the surface a very heavy blue clay was to be encountered, and that this clay held water. This stratum of clay existed throughout the entire easterly portion of the property, but dipped towards the west and disappeared about 1,000 ft. from Station 0 at the entrance.

After a careful study of the various alternative types of drainage structures, vitrified tile pipe was selected for the smaller sizes to be placed in shallow cuts, with double strength specified for the 15-in. and 18-in. sizes. For the larger sizes corrugated iron pipe was chosen. Although corrugated iron pipe is somewhat new to storm sewer construction, its long period of use as a culvert with a careful study of its performance in this field, have revealed its reaction to various soil conditions and the effects of different loads. As the result of these studies Armco paved invert pipe, which is

Shovels with Back-Hoe Attachments Were Used for Excavating

Excavator Lowering a 20-Ft. Section of 30-In. Pipe Into the Trench

plain corrugated iron pipe that has the invert or bottom protected from the erosive action of abrasive material carried suspended in water, by a pavement of a specially prepared bituminous material was selected. Besides protecting the invert of the culvert from the action of erosion, this feature offers the additional advantage of a smooth surface for dry weather flow.

Installation of Sewers.—The largest pipe used was that of 48-in. diameter needed to enclose the small stream which crossed the northwest corner of the tract. Approximately 400 ft. of pipe were used for this purpose. This line was covered to a depth of 8 ft. which made the area which the stream formerly occupied available for a number of additional burial lots, the value of which far exceeded the cost of the pipe and filling.

Both Armco paved invert pipe and vitrified tile pipe were used in the construction of the main sewer which starts at the principal gateway and extends 3,173 ft. in an easterly direction to its outlet in Irondequoit Creek. To provide drainage for burial crypts in the basement of a chapel to be constructed near this gateway, it was necessary to start the sewer at a depth of 13 ft. Throughout its entire length to the point of discharge the depths vary from 13 to 18 ft. Double strength vitrified clay pipe was used for sizes up to and including 18 in. Paved invert pipe in 30 and 36-in. diameters was used for that portion of the sewer lying between station 10 + 84 and the outlet. As was expected from records of previous excavation, the lower half of the excavation for this section of the line was through a heavy blue clay from which water oozed slowly.

Excavation for this portion of the line was done by a Bay City excavator with a back-hoe attachment. An Osgood steam shovel with a ¾-yd. bucket was used for the backfilling. In general the crew consisted of a foreman, several operators and helpers and from two to three laborers. The pipe was delivered to the job in 18 and 20-ft. lengths which were lowered into the trench by the excavator as shown in the illustration. Usually the operation of lowering a section of pipe, setting it to grade and line, and banding it to the preceding section did not exceed 15 minutes in time.

After placing a section, a sufficient amount of backfill was placed by hand to completely cover the pipe. This portion of the backfill was carefully tamped around the sides of the pipe, a worthwhile precaution which gives the flexible pipe added strength by means of side support.

When the trench had been dug ahead about 20 ft., the bottom was quickly shaped and another section of pipe lowered into place. Occasionally, portions of the sides of the trench would break off and fall into the cut before the pipe could be placed, but in general, the passage of water through the clay sides of the trench was so slow that they would stay intact until the pipe had been placed. Very shortly thereafter, however, huge masses of material would fall upon the pipe, but in no case did damage result.

In addition to the main sewer, lateral sewers with the main line as an outlet, were necessary to drain the driveways. Because of the flat topography, the roadways were designed with very slight grade, of generally ¼ per cent. To carry out the park effect, it was deemed advisable to omit paved gutters and the shoulders of the roadway were shaped to form shallow grassy gutters. On account of this fact, and also because of the flat grade, it was necessary to build receiving basins at frequent intervals, in general, every 125 ft. apart. These receiving basins discharge into the sewer by means of 8-in. vitrified tile pipe. Connections with the vitrified tile pipe sewers were made by means of a standard wye and a ⅛ bend. Where necessary to discharge into the corrugated iron pipe sewers, a hole of the proper size was made in the top of the pipe by the manufacturer. A vitrified tile wye was inserted in this hole and held firmly in place by heavy concrete rings formed around

it. The surface sewers on either side were then connected to the branches of the wye.

In addition to carrying off the surface water, the lateral sewers were designed to drain the underground sprinkling system which, when completed, will be one of the largest on the continent. The water pipes for this system are to be laid in the lanes between the burial plots and fitted with pop-up sprinkler heads to spray water over the surface, so as to keep the graves and lawns fresh and green during even the dry seasons. To date these pipes have already been installed in three of the sections and are laid on a slope so as to drain into the sewers.

Costs.—Accurate records were kept of the cost of laying 1,444.5 ft. of the paved invert pipe. These are given below in the form of man-hours per linear foot, so they can be readily adapted to meet the wage scale of any particular locality.

Item	Labor Man-Hours Per Foot	Equipment Machine-Hours Per Foot
Excavation	0.1673	.0901
Rehandle pipe	0.0067	.0001
Lay and line pipe	0.0293	.0115
Band sections	0.0276	.....
Miscellaneous work	0.0612	.0020
Backfill	0.0962	.0179
Lost time	0.1165	.0326
Supervision	0.0975	.....
Total	0.6023	.1542

Of the 1,444.5 lin. ft. of pipe on which the above costs were made, 1,242.5 ft. was of 30-in. and 202 ft. of 24-in. diameter. Excavation averaged 3.5 cu. yd. per linear foot. Miscellaneous work consisted of cleaning up around the job and the care of equipment. Lost time, which comprises quite a large item, includes time wasted by the men and other time out periods while the job was in progress. Supervision includes only the time that the foreman was not working on some item of the installation. There was considerable amount of rain while the job was in progress. While this did not stop the work entirely for any one day, it caused considerable delay. The costs as given above include only the actual time spent on the various operations directly connected with the installation of the pipe. They do not include overhead or other items of financing. Neither is the cost of constructing the manholes included. It is only by keeping these exceptions and the conditions under which the pipe was installed in mind that these figures are valuable for a comparison of any sort.

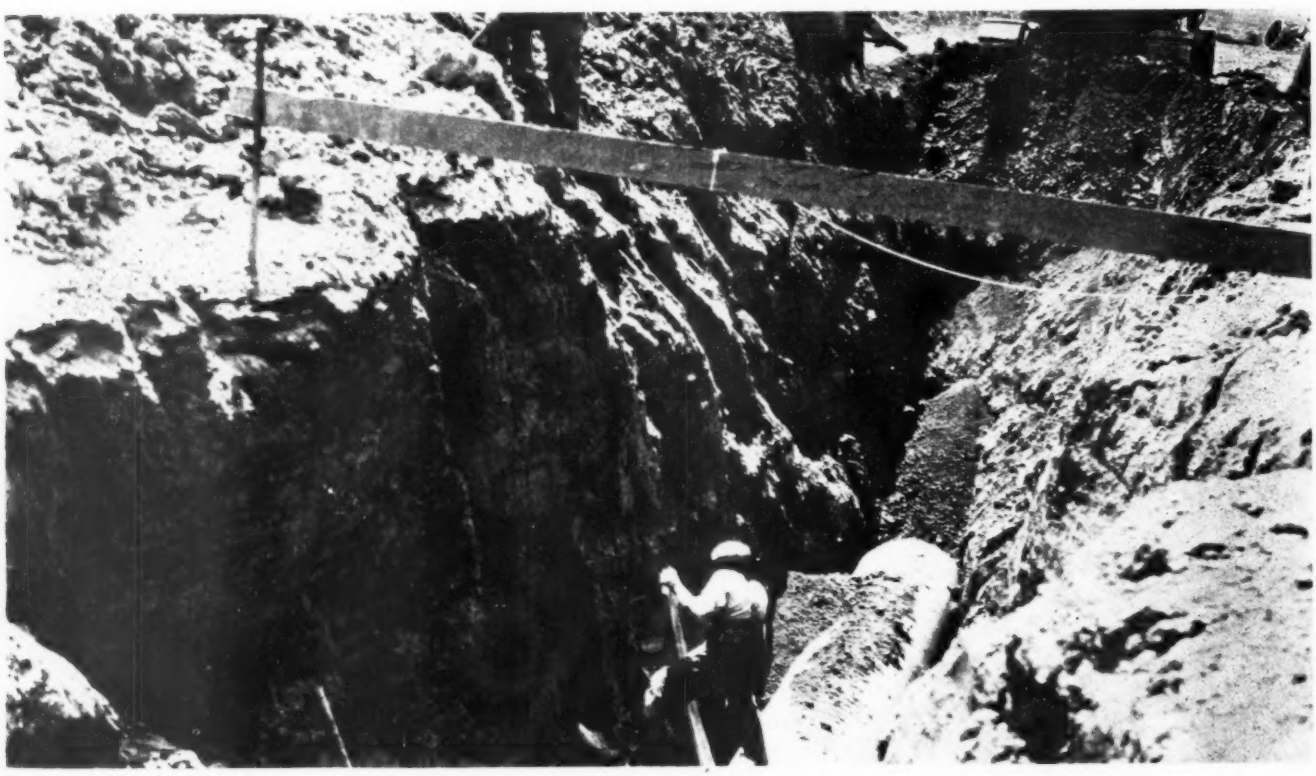
The Whitehaven Memorial Park is being developed for the Monroe Cemetery Association by the Whitehaven Development Corporation of Rochester, N. Y., for which the writer is consulting engineer. The work described in this article was designed by the writer with Mr. Francis W. Madigan, as principal assistant engineer. Mr. Shirley Williams was resident engineer in charge of construction and the contractor was Charles D. Schoen, of Pittsford, N. Y.

MONTANA WATER WORKS MEN MEET IN APRIL.—The 6th annual meeting of the Montana Section, A. W. W. A., will be held in Anaconda, Mont., April 9-10-11, 1931. The host will be the Water Department of the Anaconda Copper Mining Co. The officials of the section are: J. R. Cortese, superintendent of municipal water department, Livingston, president.

H. M. Johnson, superintendent of water department, A. C. M. Co., Anaconda, vice-president.

E. Carroll, vice-president and general manager, Butte Water Co., Butte, national director.

H. B. Foote, state sanitary engineer, Helena, secretary-treasurer.



Backfill Sufficient to Completely Cover the Pipe Was Placed by Hand and Thoroughly Tamped, the Remainder Was Made by Machine. No Bracing and Sheeting Were Used

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor
Physical Chemist, Bureau of Engineering, Chicago, Ill.

Measuring the Volume of Coagulated Matter Passing Filter Beds

The importance of watching the filtered water for flocculated matter which passes the filter beds was stressed in the December, 1930, issue of WATER WORKS AND SEWERAGE. This article gave a sketch of a device for detecting the flocculated matter, but did not give a procedure for determining the amount. Where such matter passes the beds, it is desirable to measure it so that a record of the amount may be kept. Consideration has been given to the most suitable form of expressing the measurement; that is, as to whether it should be expressed as turbidity or volume. Turbidity measurements are the best for finely divided suspended matter, but there is some doubt as to it being the most desirable form for expressing the large particles that constitute the coagulated matter which passes a filter bed.

Due to the fact that an amount of flocculated matter which will cause a turbidity of 0.1 is objectionable in filtered water, and that it is difficult to get instruments for making turbidity measurements lower than 0.1, it seems desirable to use a volume measurement even though the volume has to be determined in an indirect way. The writer has made use of the volume measurement for several years, and it has been found to be fairly reliable and almost as easily made as a turbidity determination. To be based upon a volume measurement, there should be some means of actually determining the volume under conditions that may be duplicated time after time.

Methods of measuring the volume of a precipitate heretofore have been by a cone or some similar device. Coagulated matter settles so loosely in a measuring cone that this means of determining the volume is not very accurate. Not only this, but a fairly long period of standing is required. Compacting the flocculated matter with a centrifuge which is operated at a constant velocity probably comes nearer giving results that may be duplicated with considerable accuracy than any other procedure. It is evident that such minute amounts of flocculated matter as usually pass a filter bed cannot be determined with a centrifuge, or at least it would require the centrifuging of such a large volume of the water that it would not be practical to make such a test. What is done is to measure with a centrifuge the volume in a more concentrated sample and make standards by diluting so as to cover the range likely to occur in the water. The writer[1] described a procedure for making flocculated turbidity measurements several years ago. This procedure was later modified to the present one. So far as can be found, this is the only reference in the literature on measurements of the volume of very minute quantities of gelatinous precipitates. In this case the volume was determined as turbidity.

Equipment.—Several pieces of equipment which may not be found in the average water works laboratory are required for accurate results. It is desirable to have a centrifuge which will hold at least two 100-cc. Goetz tubes. As these are glass tubes it is better to have several extra tubes on hand to replace breakage. These tubes have a small graduated arm where the precipitate is concentrated. The graduated portion should hold at least 0.1 cc., and should be graduated to 0.01 cc. The capacity of the graduated arm on most of the tubes now being sold is 0.2 cc. The centrifuge should be capable of maintaining a speed of at least 1,600 revolutions per minute. Where there are a number of samples to be tested a head to hold 4 tubes will hasten the work. Where most of the samples are filtered water that have to be compared with standards, a head for two tubes is all that is necessary.

A floc detector suitable for laboratory uses is shown in Fig. 1. This is very much like the one illustrated in the December issue, except that a place is provided for two flasks. The light is between the flasks. The floc detector will have to be made special, or at least no one is now manufacturing such an instrument. The box should be painted dull black on the inside. Two-liter or three-liter flasks, florrence or round bottom, are suitable. The size and kind of flasks will have to be decided upon first and the box made to suit the flasks selected. The writer has used both kinds and both sizes of flasks, and finds very little difference in their serviceableness. The three-liter size may be slightly more accurate, but the two-liter size is more convenient to handle and does not require quite so large a sample. It is more convenient to have a number of flasks so that the standards containing various amounts of the flocculated matter may be prepared and kept stored in the flasks. Other equipment needed in the preparation of the standards is usually found in well equipped water works laboratories. A laboratory stirring machine is convenient where standards have to be prepared frequently, but this can be done by hand if a machine is not available.

Procedure for Measuring the Volume of Coagulated Matter with the Centrifuge.—This procedure is for measuring the volume of coagulated matter where the amount is sufficient to obtain a measurable quantity by centrifuging the sample. It is applicable to all coagulated waters prior to sedimentation, and also to the settled water in most filtration plants. When the amount of sediment is very small, as is the case for the effluent from the settling basins at some of the filtration plants, the process of centrifuging an amount sufficient to obtain an accurate measurement becomes laborious. The

[1]Baylis, John R. Sensitive detection of suspended matter and a proposed standard of clarity for filtered water. J. Am. Water Works Assoc., 11: 824-32, July, 1924.

floc detector is more convenient in such instances. Where the volume of flocculated matter is less than about 75 volumes per million volumes of water it is usually more convenient to make determinations by comparing with standards. This corresponds to a turbidity measurement of about 5, determined in the customary method of making such determinations.

Place 100 cc. of the sample containing the flocculated matter in one of the Goetz tubes, taking care to have the flocculated matter evenly distributed throughout the sample when the portion is being withdrawn. The tube must be balanced by another tube containing the same amount of water. Another sample may be tested at the same time or a check test run on the sample. If a 4-tube head is used, 4 samples may be centrifuged at one time. Set the centrifuge to run at about 1,500 revolutions per minute. The speed should be not less than 1,400 nor more than 1,600 revolutions. It is desirable to check the speed occasionally to make sure that it falls within the limits set. Run the centrifuge for 5 minutes, cut off, remove the Goetz tubes and rub the inside wall with a rubber policeman so as to break loose any suspended matter adhering to the glass. Replace the tubes in the centrifuge and run again for about 2 minutes, or until all the flocculated matter has been thrown down into the small arm of the tubes.

If the 100-cc. portion gives more than 0.01 cc. of sediment in the small arm of the tube, record the amount as the initial volume. Should there be less than 0.01 cc. of sediment, decant the water and fill with another 100-cc. portion of the sample. The sediment in the small arm of the tube will not be disturbed by the decanting. Repeat the centrifuging of 100-cc. portions until there is at least 0.01 cc. of sediment. Read the volume to the nearest 0.001 cc. It is evident that a reading of 0.001 cc. cannot be made exactly when the tube is graduated only to 0.01 cc., but the reading may be approximated fairly closely. After obtaining the initial reading centrifuge a large enough portion of the sample to obtain an accurate reading. The amount required will vary, but a 100-cc. portion usually will be enough if the water has been coagulated with more than about 20 parts per million of the coagulant and none of the flocculated matter has settled out. From 200 to 1,000 cc. of the settled water may be required to give an accurate reading. Where more than 300 cc. are required it is usually more convenient to use the procedure which will be outlined for comparison with standards.

The reason why it is necessary to start with some sediment in the small arm of the tube is that the first graduation on the tube might not be exact, and also because there is a slight compacting of the sediment as the amount accumulates in the small arm of the tube. This is shown by Table I, in which water with a turbidity of 25 was treated with 30 parts per million of aluminum sulfate.

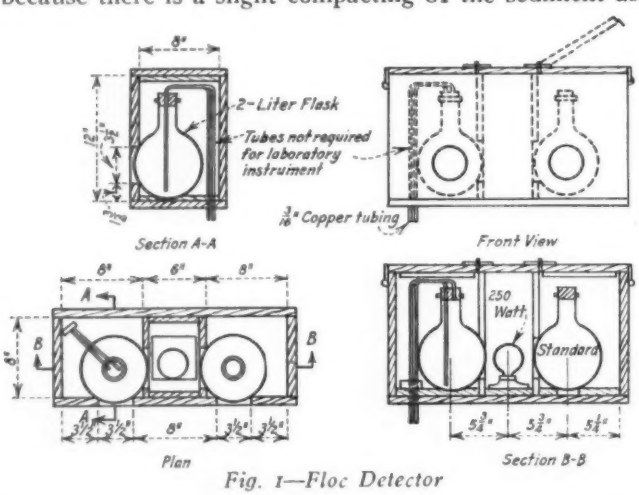


Fig. 1—Floc Detector

The table shows that by centrifuging successive 100-cc. portions of the sample the volume increases almost in proportion to the amount centrifuged, except for the first 100 cc. It also shows the importance of having a little sediment in the small arm of the Goetz tube before the test is made. The first 100 cc. centrifuged had a volume of 0.040 cc. of sediment. This constitutes the initial reading. The reading after centrifuging 200 cc. was 0.067 cc., which gives a volume of 0.027 cc. of sediment for the second 100 cc. portion. This should be used for the measurement of the volume of coagulated matter in the water and not the volume obtained with the first 100-cc. portion. If samples similarly treated are to be tested, successive 100-cc. portions may be centrifuged without throwing out the sediment already in the small arm of the tube. The capacity of the graduated portion of the arm is usually 0.2 cc.

To clean the sediment out of the arm of the Goetz tube, a small glass tube about 4 to 5 mm. outside diameter is heated and drawn out to where the small end fits quite loosely into the small arms of the Goetz tubes. The tube, including the drawn-out portion, need not be over 6 in. long. With a rubber bulb on the large end of the tube it is partially filled with water and pressed down to the bottom of the small arm of the Goetz tube. Pressing on the rubber bulb forces water out and washes out the small arm.

How the centrifuged sediment compares in volume with that in settling basins is not definitely known, but the fact that the sediment soon reaches a maximum compactness in the Goetz tube indicates that its density is somewhere near that of the sediment in a settling basin, except the top 6 to 12 in. This procedure gives a volume measurement that is at least somewhere near that of the coagulated matter after it has compacted itself in a settling basin.

Measurement of the Volume of Small Amounts of Coagulated Matter by Comparison with Standards in the Floc Detector.—It is difficult to form much idea of the volume of coagulated matter in water by turbidity measurements on account of the large size of the individual particles, and the fact that light will pass through some gelatinous precipitates more readily than others. The amount of fine suspended matter that has not been entrapped in the coagulated matter also will effect the turbidity determination. Owing to the fact that the coagulated matter is the same, whether it is from the mixing basin, the settling basins, or the filtered water, it seems best to make all measurements in terms of the volume rather than the turbidity. It is necessary to use a floc detector for making tests where the amount passing the beds is low and to compare with standards, so it it just as easy to have the standards represent a certain

Table I—Volume of Coagulated Matter Measured With Centrifuge

Total CC. Centrifuged	Total Volume of Coagulated Matter in CC.	Volume of Coagulated Matter in the Last 100 CC. Centrifuged
100	.040	.040
200	.067	.027
300	.092	.025
400	.118	.026
500	.144	.026
600	.168	.024
700	.192	.024

volume as it is to have them represent a certain turbidity. This test is one primarily to determine the amount of coagulated matter passing filter beds, but it is applicable to settled water that has been previously coagulated where the amount of coagulated matter is small as is the case in some filtration plants having good mixing and settling basins.

Preparation of Stock Solution to Be Used in Making Standards.—It is believed that the coagulation of water of a certain turbidity with a definite quantity of coagulant will serve best for making standards. This constitutes the stock solution, and the actual volume of the flocculated matter is measured with the centrifuge. The stock solution is then diluted to the desired standards to cover the range likely to occur in the water being tested. All comparisons of samples with the standards should be made in the floc detector shown in Fig. 1. The procedure that will be given is for water coagulated with aluminum sulfate, but a similar procedure may be used for other coagulants:

Add an excess of Fuller's earth to distilled water, mix thoroughly, and allow to stand about 2 hours without agitation. Decant the supernatant liquid and test with a Jackson candle turbidimeter. Estimate the dilution to give a turbidity of 25, using distilled water to make the dilution. Again test with the Jackson candle turbidimeter and make further adjustment to get a turbidity of 25 if it is more or less than this figure. Add 100 parts per million of sodium bicarbonate, mix thoroughly, then add 30 parts per million of aluminum sulfate. The aluminum sulfate should be commercial alum containing 17 per cent of Al_2O_3. Stir for 15 minutes at a velocity that will form large individual particles of coagulated matter. Centrifuged portions of the sample usually give a volume somewhere near 0.025 cc. per 100 cc. of the solution, or 250 volumes of coagulated matter per million volumes of water. Where a centrifuge is available the stock solution volume should be determined by actual measurement, but if a centrifuge is not available the figure given will not be greatly in error.

Preparation of Standards of Definite Volumes.—Dilutions of any desired proportion to give standards of procedure for centrifuging the sample has been given. the desired volumes may be made. The dilution water should contain the same amount of sodium bicarbonate as that of the stock solution. The dilution water also should be brought to the same pH as that of the stock solution by the addition of a little sulfuric acid. This pH is about 6.7. Standards of 0.25, 0.50, 0.75, 1.0, 1.5, 2.0, 3.5, 7.0, 10.0, 15.0 and 20.0 volumes of coagulated matter per million volumes of water will likely cover the range needed for most filtered waters. It may be desirable to go higher if settled water is being tested with standards. If the stock solution contains exactly 250 volumes of flocculated matter per million volumes of water, a standard of 1.0 volume is prepared by diluting 8.0 cc. of the stock solution to 2 liters. The other standards are in the same proportion; that is, a standard of 2 volumes is made by diluting 16 cc. of the stock solution to 2 liters.

Most of the filtration plants may prefer to use the coagulated water from the mixing basin effluent for preparing standards. Where the laboratory is equipped with a centrifuge there is no objection to doing this. In fact it may be slightly more accurate for the particular plant than the standards made as outlined in the previous paragraph.

Simplified Procedure for Approximate Determinations.—Where laboratories consider it too laborious to prepare accurate standards, approximations may be made by a more simple procedure. The volume of coagulated matter is somewhat in proportion to the amount of coagulant used. Approximately 8 volumes of flocculated matter per million volumes of water is produced for each part per million of aluminum sulfate applied to the water. If the water is being treated with 17.1 parts per million (1.0 grain per gallon) of aluminum sulfate, the volume of coagulated matter should be somewhere near 137 volumes per million volumes of water.

Take two liters of clear filtered water, and filter through paper if there is any possibility of flocculated matter being present. Add flocculated water from the mixing basin effluent until the water contains as much flocculated matter as is in the sample being tested. Use the floc detector for making comparisons. The amount of flocculated water from the mixing basin should be measured accurately. Assume that 1.2 grains per gallon of aluminum sulfate was added to the water in the mixing basin. The mixing basin effluent would then have approximately $8 \times 1.2 \times 17.1$, or 164 volumes of flocculated matter per million volumes of water. If 10 cc. of the mixing basin effluent was required to give a flocculation that matches the sample, the approximate volume of coagulated matter in the sample is

$$\frac{164 \times 10}{2{,}000} = 0.8$$

volume. This procedure requires very little labor and while not exact is better than no measurement.

Small Amount of Flocculated Matter Usually Overlooked.—Eight-tenths of a volume of coagulated matter per million volumes in filtered water probably would not cause suspicion, for it would not increase the total turbidity more than about 0.1 to 0.2. A turbidity of 0.2 is regarded as about the desired standard of clarity for filtered water, so if the total turbidity, both fine and flocculated, does not exceed this figure the operator will think that every thing is all right. Should the total turbidity run up to 0.3 to 0.4 it causes no alarm and the operator thinks that not quite enough coagulant is being added. Usually the first thing he does, if the filters are not equipped with floc detectors, is to increase the coagulant. There might have been nearly 0.2 fine turbidity in the water, and the increase in coagulant might reduce this to less than 0.1. If by doing this the total turbidity is reduced to 0.2 to 0.3 the operator usually assumes that the water is just a little more difficult to coagulate than usual and probably makes no additional effort to further improve conditions. As a matter of fact the same quantity of objectionable flocculated matter may continue to pass through the filter beds.

The addition of sufficient aluminum sulfate to water of a certain turbidity to properly coagulate it does not change the turbidity very much. In most instances it is believed the turbidity will be decreased, when determined in the usual manner with a Jackson candle turbidimeter or by comparison with standards. A volume of flocculated matter that increases the turbidity of the filtered water 0.2 is equivalent to bypassing 1 per cent of the mixing basin water directly into the filtered water when the flocculated turbidity of the mixing basin water is 20. We would go to an enoromus expense to prevent this amount of mixing basin water being bypassed into the filtered water, yet many filter operators think nothing of allowing much more than this amount of flocculated matter to pass the filter beds. Some operators do not become alarmed at a turbidity of 1.0 in the filtered water, though they usually try to

keep it less than this figure. This, if it should be flocculated turbidity, is equivalent to bypassing 5 per cent of the mixing basin water directly into the filtered water when it has a turbidity of 20.

It is nothing uncommon to find filters in well operated filtration plants passing enough flocculated matter to give a turbidity of 1.0 just before the filter is washed. With a flocculated turbidity of 10 going on to the filters, this is the same as bypassing 10 per cent of the water directly into the filtered water. The filter, of course, will not average this amount. It might filter the water perfectly clear for 20 to 24 hours before the flocculated matter starts passing the bed. If the filter will run 24 hours without passing any flocculated matter, and then the flocculated matter increases from zero to 1.0 turbidity within the next 24 hours, the average flocculated turbidity for the 48 hours the filter is in service is about 0.25. This is assuming that the increase in turbidity was at a gradual rate. In plants equipped with floc detectors the operator should wash the filter as soon as it begins to pass flocculated matter, which in this case would be after about 24 hours' service.

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The Drought and Water Supplies in Ohio

As a result of the drought which has prevailed in Ohio for the past 10 months the water supply situation in many of the smaller municipalities has been in a somewhat critical state. A ½-in. rainfall early in January improved conditions, reports received by the State Health Department indicating a substantial amelioration of the crisis in many localities. The Jan. 15 issue of Ohio Health News, the official publication of the department, comments on these reports as follows:

Blanchester seems to have been the only village transferred to the safe side of the line. With almost exactly ½ in. of precipitation, 3,000,000 gal. of water were taken into the collecting basin at a time when orders had just been issued to the B. & O. R. R. to begin delivery of 25,000 gal. daily from Loveland, in tank cars. As the Blanchester requirement is 25,000 to 30,000 gal. daily, the village has 100 days' supply in hand. Conditions also are being bettered for the future by needed repairs to the storage basin, which will enable it to be filled, for the first time since it was built, as soon as rainfall and run-off are sufficient.

At Woodsfield there was sufficient rain so that the level of water in the reservoir was raised about 3 ft. above the minimum of Dec. 1, when no more could be drawn from it to the filtration plant. Present flow in Sunfish Creek is more than sufficient to meet the daily requirements of the village.

At New Concord, where the regular supply had long been exhausted and mine water was being pumped, an intercepting ditch and collecting basin had been constructed in readiness for rain. The first muddy flow was allowed to waste and then the improvised reservoir was filled with approximately 500,000 gal., or about 15 days' supply.

Duck Creek, at Caldwell, had run dry, and water from a few small wells was insufficient to meet village needs until the rain of Jan. 5. Mains were flushed and filled, and present flow in the creek is meeting present needs. Last report was on Jan. 13; but without additional rain there is no guaranty as to how long the flow will be edaquate.

Barnesville was the only place reporting which did not seem to have benefited from rain. In five weeks, the last of which included the days of precipitation, water level in the aerating chamber at the filtration plant was lowered from 42 to 12 in. over the floor, or a loss of 6 in. a week. Water level is 22 ft. below the crest of the storage dam, which leaves only 14 ft. in the narrowest part of the prism. When the water level reaches the floor of the aeration chamber it will be necessary to reverse the line of flow in the filter plant drainage pipe and pump raw water, by-passing the filter, despite the fact that the village supply is relieved of a load of 50,000 gal. daily by the development of a small supply for its own use by the dairy plant which is the largest local industry.

Last report was on Jan. 11, which indicates that if there is no local rain of sufficient magnitude, the village will go on raw water Jan. 25. The Barnesville drainage basin consists of only 510 acres, so that heavy precipitation, at regular intervals, is necessary if a supply is to be maintained.

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Design of Sanitary Drinking Fountains

Essential features in the design of sanitary drinking fountains were covered by the committee on plumbing of the public health engineering section of the American Public Health Association in a report presented at the 1929 meeting of the association. Following the issuance of the report further study was given the subject, and the conference of State sanitary engineers at their 1930 meeting, according to Public Health Reports, adopted the following as essential features of design, construction, and operation of drinking fountains:

1. The fountain shall be constructed of impervious material, such as vitreous china, porcelain, enameled cast iron, other metals, or stoneware.
2. The jet of the fountains shall issue from a nozzle of nonoxidizing, impervious material set at an angle from the vertical. The nozzle and every other opening in the water pipe or conductor leading to the nozzle shall be above the edge of the bowl so that such nozzle or opening will not be flooded in case a drain from the bowl of the fountain becomes clogged.
3. The end of the nozzle shall be protected by nonoxidizing guards to prevent persons using the fountain from coming into contact with the nozzle.
4. The inclined jet of water issuing from the nozzle shall not touch the guard, thereby causing splattering.
5. The bowl of the fountain shall be so designed and proportioned as to be free from corners which would be difficult to clean or which would collect dirt.
6. The bowl shall be so proportioned as to prevent unnecessary splashing at a point where the jet falls into the bowl.
7. The drain from the fountain shall not have a direct physical connection to a waste pipe unless the drain is trapped.
8. The water supply pipe shall be provided with an adjustable valve fitted with a loose key or an automatic valve permitting the regulation of the rate of flow of water to the fountain so that the valve manipulated by the users of the fountain will merely turn the water on or off.
9. The height of the fountain at the drinking level shall be such as to be most convenient to persons utilizing the fountain. The provision of several steplike elevations to the floor at fountains will permit children of various ages to utilize the fountain.
10. The waste opening and pipe shall be of sufficient size to carry off the water promptly. The opening shall be provided with a strainer.

The Design of Earthen Embankment, Masonry Lined Distribution Reservoirs

Preliminary Surveys and Investigations—Excavation and Embankment Slopes—Selection of Embankment Materials—Protection of Outlet Pipes—Embankment Construction—Reservoir Lining—Reinforcement—Expansion Joints—Water Proofing—Costs

By CHESTER A. SMITH
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ACCURATE contour maps should be made of each possible available site or of the site selected, and after perhaps several trial layouts of the reservoir as to capacity desired or available, the shape and the approximate depths of excavation determined, test pits or borings should be made to determine the character of material encountered in the excavation as well as the character of soil beneath the bottom of the reservoir, or under the embankment.

An economical design is generally one where the amount of excavation, minus the waste of the top soil stripping, will balance the amount of material necessary to form the embankment. However, the borings may show soil conditions that will require considerable wastage in excavation in order to secure good foundation conditions or to secure proper materials for forming the embankment. The test pits or borings may show wide variations in the kinds of material in the strata or in various portions of the reservoir, and it may be necessary to temper or to mix the varying materials as they are placed in the embankment. Through knowledge of existing soil conditions and provisions made in the specifications for mixing classes of excavation sometimes saves a great deal of argument between the engineer and contractor.

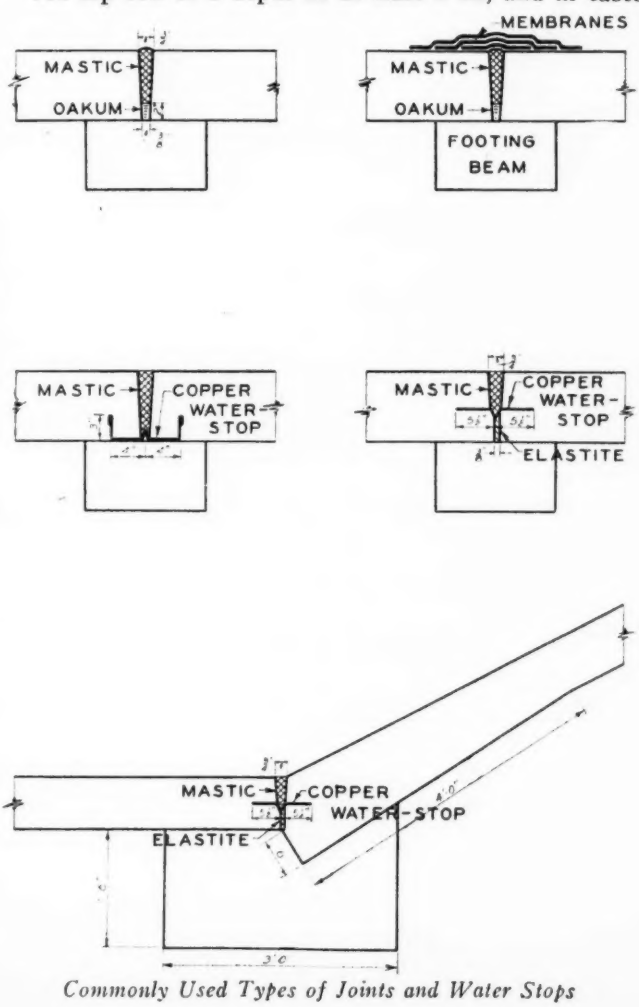
Excavation and Embankment Slopes.—The character of the material will govern to a certain degree the slope of the excavation and embankment. The slopes should not be greater than the angle of repose of the material when saturated. Excavation slopes for interior embankments are generally not less than 1½ to 1. This slope is about as steep as a concrete lining slab can be safely and properly placed upon without the use of forms, and, is approximately the limit of the angle of repose for a stiff workable concrete, without causing slump cracks. Steeper slopes in shale excavation, or other hard materials have been used with a gunite lining. Inside earthen embankments should never be less than 1½ to 1 and for high embankments, and particularly with certain soils, a 2 to 1 slope is preferable.

The outside slope of an embankment should be at least 1½ to 1, and 2 to 1, or 2½ to 1, is preferable for high embankments.

Selection of Embankment Materials.—The ideal material for embankment construction, is a mixture of clay and sand, fine gravel or decomposed granite, well pulverized, that will bind together when moistened and rolled. Clays, adobes and certain kinds of soft shales, will swell when moistened or wet, and shrink and contract when dry. Certain types of finely divided silt deposits, or, in some sections of the country, soils termed, "volcanic ash," are very treacherous for use in reservoir construction. The material seems to shrink or dissolve when moistened and flow readily at a very low angle of repose. Where this material is available only for embankment, extreme precautions must be taken to avoid leakage by water tight construction in the lining. The more or less sudden change in soil characteristics in excavation, either in the bottom or side slopes, require careful consideration in design and construction. Where such changes occur, the excavation should be made from a 6 in. to 1 ft. deeper, and then refilled and compacted with a mixed or homogeneous material.

In the construction of oil reservoirs for the Shell Oil Co., the excavation for the side slopes was made about 6 ft. wider than the finish line, and was then refilled and compacted with tempered and selected material. The idea or principle followed in this method, is that in large reservoirs the soil strata will not be found uniform, hence unequal shrinkage or settlement will occur, which must be avoided if the lining is to remain solid.

All top soil to a depth of at least 6 in., and in cases



Commonly Used Types of Joints and Water Stops

greater depths should be stripped from the reservoir site, and not used in any embankment or reservoir construction. If a dry waterway, wash or gully runs through the reservoir, care should be taken that all porous or silt and detrital deposits are removed and the excavation refilled and compacted with selected material. It is usually good practice to have the entire reservoir bottom extend into solid natural soil, but it is not always practically possible, or feasible. Where suitable material is available for mixing, tempering, wetting and compacting, the reservoir may be safely constructed partially upon filled ground. Some engineers claim that a better embankment or foundation can be made by man and machinery than nature has made by her forces.

Protection of Outlet Pipes.—All pipes entering the reservoir, as the water supply main, drain and clean-out lines and underdrainage system outlets, should be laid in trenches excavated in the original firm soil when possible, before any embankment is placed. The pipe lines should be designed to support the weight of the backfill and embankment. Pipe lines passing beneath high embankments should be laid in concrete cradles supporting the lower quarter or half of the pipe, as may be necessary. Concrete cut-off walls or collars to prevent seepage along the outside surface of the pipe, should be constructed every 20 to 30 ft. apart, at right angles to the pipe line. These walls should extend approximately 1 ft. or more below the bottom and into the sides of the trench and also 1 ft. above the junction of the natural ground and embankment.

A concrete collar or thickened slab should be provided around the pipe opening into the reservoir lining. In some cases an expansion or movement joint is provided separating the pipe collar and lining slab.

Embankment Construction.—The safety of the reservoir depends largely upon the solidity and strength of the embankments, hence they should be designed and constructed with the same care and same principles as an earth dam.

After all top soil, roots and permeable material has been stripped from the surface upon which the embankment is to be constructed, the original earth should be plowed, and harrowed thoroughly until well pulverized and mixed, then moistened and rolled and compacted.

The excavated material placed in the embankment should be spread uniformly over the required area in horizontal layers not to exceed 6 in. in depth, then moistened, cultivated and harrowed, until thoroughly pulverized and mixed. Care should be taken in wetting not to produce a springy or quaking condition when rolled and compacted. All rocks or boulders larger than 4 in. in diameter, tree roots, wood or other larger particles of organic matter, should be removed before rolling.

The most satisfactory method of rolling and compacting is by the use of a heavy roller having a number of projecting lugs about 4 in. to 6 in. long on the roller wheels, or what is termed a pethrolithic tamper or "sheep's foot" roller.

The inside embankment should be carried approximately 18 in. beyond the finished line for the base of the lining, in order to give working space for the tamper or roller to thoroughly compact the embankment. After completion of the embankment this excess embankment width should be trimmed off by hand to exact subgrade for the lining.

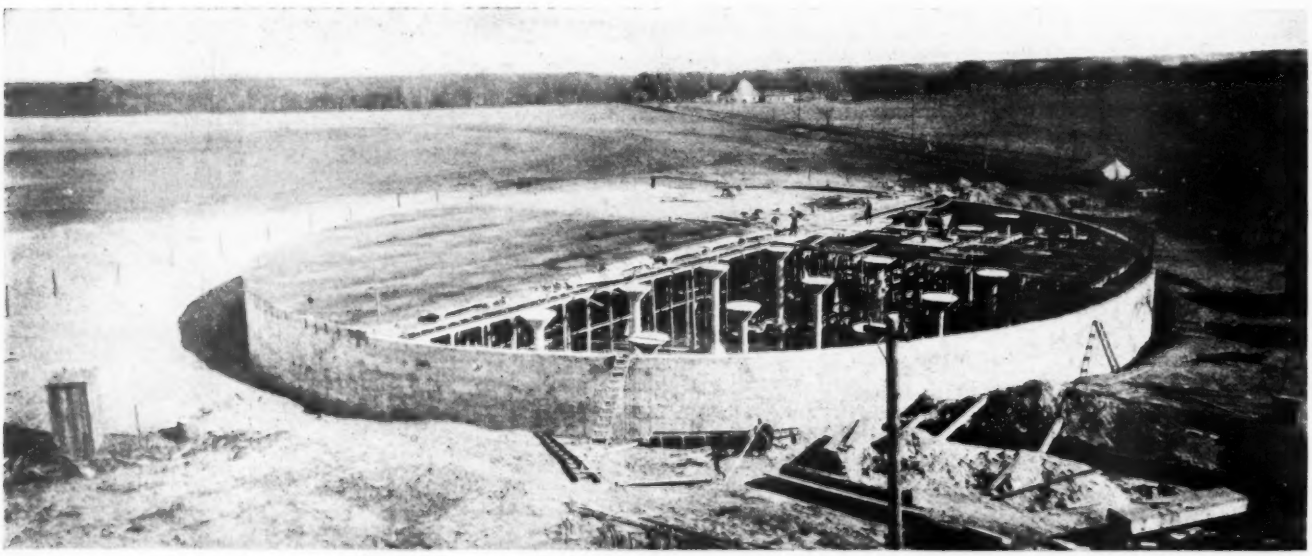
Density and tenacity of material in the embankment is practically necessary for a safe structure of this type. If the embankment runs to too great a percentage of sand, gravel, loose rock or disintegrated granite, it may be necessary to borrow or haul in clay, loam or other fine binding material to fill the voids in the main excavated material. The grading and percentage of fine and coarse material is similar to the proper portioning of a concrete mixture.

When sufficient clay or material of this nature cannot be economically secured for making a firm and practically impervious embankment, then greater care should be taken to secure a watertight lining.

Reservoir Lining.—Reservoirs constructed 30 to 40 years ago, were generally lined with brick or rubble stone masonry and water tightness was secured by mixing and puddling the soil beneath this lining. Practically all modern construction employs some type of reinforced concrete or gunite for floors and lining.

A dense concrete is desired, and the proportioning of aggregate should be approximately 1 part cement, 2 parts sand, and 4 parts rock or coarse aggregates, the relative proportions varying with the local character of the sand and coarse aggregate. For sloping walls, the water content should be kept low as possible to secure a good workable mixture. Some specifications call for a slump test not to exceed 1 in.

The required thickness of floor slab and the slab for



Construction View of 2,000,000 Gal. Reservoir for Ponca City, Okla. This Is of Ring Tension Type with Flat Slab Concrete Roof

side slopes, depends somewhat upon the character of the soil and embankment. Under the most favorable conditions, the minimum thickness should be at least 4 in.

Unless exceptional local conditions require heavier construction, a well proportioned and compacted concrete slab thicker than 8 in. is not necessary for water depths up to 40 ft.

A number of reservoirs have been lined with gunite, ranging in thickness from 1½ in. to 4 in. A double concrete slab with a fabric waterproof membrane between the slabs or bottom slab of concrete supporting the membrane with the top or cover slab of gunite, has been used in several designs.

Reinforcement.—"Chicken" wire fencing, expanded metal, welded wire fabric, and steel bars, have been used for slab reinforcing and in some cases, apparently, there has been little thought given to the function of the reinforcing, and its placing and required steel area. The earth foundation or embankment should be designed and constructed to support the water pressures and super-imposed loading, and the slab is not designed to resist bending moments over any particular span between supports. The reinforcement is to care for temperature, curing and drying stresses within the slab. In "Concrete Building Construction," Crane & Nolan, it is stated that concrete expands with moisture during curing, about .02 of 1 per cent, and contracts upon drying out .06 of 1 per cent in length.

The action of contraction and expansion due to temperature changes, is well known. "Contraction is often more serious although cracks are by no means necessarily dangerous," is quoted in "Concrete, Plain and Reinforced," by Taylor, Thompson and Smulski.

The percentage of steel area should range from .2 of 1 per cent to .4 of 1 per cent of the cross sectional area of the concrete slab. The lower value being used in floor and side wall slabs where reservoirs are covered and not subject to great ranges in temperature changes. Some authorities recommend the higher limit for special watertight work.

The steel should be well embedded in the slab and for slabs 4 in. to 6 in. in thickness, the steel placed in the center rather than trying to place it in the lower section to obtain bending strength will obtain better results for the real purpose of the steel. In many cases where concrete slabs have been removed or examined, the steel has been found exposed on the lower surface of the slab, or so lightly embedded that it practically has no bond with the concrete.

Woven or welded wire fabrics have their advantage in usually higher tensile strength and give a more uniform and closer spacing of the reinforcement, however, their disadvantages are that the material is "springy" and hard to hold in the proper position, during construction. Steel bars of proper size and spacing are more easily placed and held into position, especially with the use of "chairs."

Expansion Joints.—There is a wide difference in opinion or at least in the general practice in the spacing and use of expansion joints. The object of a joint, as stated by Crane & Nolan, "is to provide a plane of separation so that free movement of two adjacent parts may take place." Therefore, the term "expansion joint" as commonly used, may be better defined especially in reservoir construction, as a "movement joint," as the movement may be from contraction and expansion, or from an unequal settlement of the supporting earth. It is the writer's opinion that joints should not be spaced over 35 to 40 ft. apart for expansion and contraction in well reinforced slabs, and prefers in most cases less distances between joints. Where unequal settlement may occur due to a slab extending over an area made up of excavation and embankment, joints should be provided every 15 to 20 ft.

Inasmuch as the joints were expected to move, the joint should be made of a type that will allow movement and still remain watertight. Two principal types are used—one with a flexible metal stop or tongue with the

Completed Reservoir of Ponca City Okla. *(See page 38.)* *Contract Cost Was $35,850*

Table I—Earth Embankment, Covered Reservoirs

Location	Year Built	Capacity	Water Depth	Slopes Inside	Slopes Outside	Slab	Reinforcement	Expansion Joints	Total Cost	Cost Per Million Gal.	Type of Roof
Burbank, Calif.	1926	348,000	14'-0"	0.4:1		6"	Wire Mesh	Asphalt	13,716	40,000	Wood frame & paper. Rwd Cols
Riverside, Calif.	1913	500,000	16'-0"	1½:1		6"	Steel Bars	Asphalt	7,700	15,400	Wood
Pasadena, Calif.	1926	638,000	18'-0"	¼:1		1½"	Wire mesh-Gunite	None	11,992	18,885	Wood on Rwd Columns
Pasadena, Calif.	1921	984,000	18'-0"	¼:1		1½"	Wire mesh-Gunite	None	14,538	14,800	Rwd. roof & Columns
Pasadena, Calif.	1928	1,023,600	20'-0"	1:1		3"	Wire mesh-Gunite	None	18,403	18,000	Armco Iron - Rwd Cols.
Santa Barbara, Calif.	1897 1927	1,500,000	20'-0"	1.4:1	1½:1	2"	Wire mesh	Asphalt	15,730	10,450	Paper on wood Galv I. Pipe Cols.
Santa Barbara, Calif.	1932 1917	1,500,000	20'0"	1.4:1	1½:1	5"	Wire mesh	Asphalt	* 8,500		Wood on pipe cols. * Lining & roof only
San Diego, Calif.	1909	2,448,000	12'-0"	2:1	1½:1	4"	Steel bars		11,600	4,750	Wood on Concrete Columns.
Burbank, Calif.	1930	2,500,000	20'0"	2:1	1½:1	6"	Steel bars	Asphalt	38,346	15,450	Paper on wood. Rwd Columns
Riverside, Calif.	1913	3,000,000	16'-0"			6"	Steel bars	Asphalt	21,500	7,200	Wood
Glendale, Calif.	1929	3,500,000	30'-0"	1½:1 2:1	2:1	8"	Expanded metal	Copper	49,000	14,200	Paper on wood. Rwd Columns
Palo Alto, Calif.	1927	3,800,000	16'-0"	1.8:1	2:1	6"	Steel bars	Asphalt	37,566	9,900	Paper on wood. Conc Columns
Fullerton, Calif.	1922	5,000,000	13'-0"	2:1	3:1	4"	Wire mesh	Asphalt	49,350	9,900	Wood on Conc Columns
Phoenix, Ariz.	1924	5,000,000	17'-4"	1¼:1	3½:1	6"	Wire mesh	Asphalt	46,600	9,340	Corrugated Iron on Wood
Oceanside, Calif.	1929	5,000,000	17'-0"	1:1	1¼:1	2"	Wire mesh-Gunite		48,975	9,800	Twin Reservoir-Paper on wood. Conc C.
Whittier, Calif.	1921	6,632,000	24'-0"	2:1	2½:1	4½" 6"	Wire mesh	Asphalt	64,000	9,660	Wood on Conc. Columns.
Pasadena, Calif.	1917	6,932,000	18'0"	1:1	2:1	4"	Wire mesh	None	21,128	3,200	Rwd on Rwd. Cols
Burbank, Calif.	1928	6,900,000	20'-0"	2:1	1½:1	6"	Wire mesh	Asphalt	67,436	9,800	Paper on wood. Rwd. Cols.
Glendale, Calif.	1920	7,500,000	20'-0"	2:1	1½:1	4"	Wire mesh	Asphalt	60,800	8,100	Wood on Rwd. Cols.
Phoenix, Ariz.	1928	10,000,000	16'-0"	1:1	3½:1	6"	Wire mesh	Asphalt	88,800	8,880	Corrugated Iron on Wood
San Bernardino, Calif.	1929	10,000,000	30'-0"	½:1	1:1	2" 4"	Wire mesh-Gunite	None	51,931	5,193	Metal on Wood . 6" Pipe Columns
Pasadena, Calif.	1925	10,277,500	20'-0"	1½:1	2:1	6"	Wire mesh	None	49,357	4,800	Wood on Rwd. Cols.
Riverside, Calif.	1927	12,000,000	26'-0"	1½:1	2:1	2"	Wire mesh-Gunite	None	60,000	5,000	Paper on Wood. Conc Cols.
Glendale, Calif.	1924	13,000,000	20'-0"	2:1	2:1	6"	Wire mesh	Asphalt	78,190	5,200	Wood on Rwd. Cols.
Glendale, Calif.	1925	15,000,000	20'-0"	2:1	3:1	6"	Wire mesh	Asphalt	84,475	5,620	Wood on Rwd. Cols.
San Bernardino Calif.	1926	3,215,000	10:0	2½:1	2:1	4"	* Lined asphaltic oil		7,560	2,350	Galv I. on Wood - 4" Pipe Cols.

ends embedded in the adjacent slab, and the second with a plastic or mastic filler that will compress or expand with the movement and keep the joint sealed. Soft copper and lead are the most generally used metal stops, and a compound with a coal tar pitch or asphaltum base, is used for the mastic filler. In addition to the mastic filler, one or more layers of a cloth fabric saturated with asphaltum or pitch, mopped on over the joint with the ends extending from 6 to 12 in. onto the adjacent slabs is used to provide an additional water seal. The accompanying stretch shows some of the more commonly used type of joints and water stops or fillers. Some interesting tests with these various types of joints were conducted by P. Diederich, water superintendent of Glen-

Table II—Earth Embankment, Uncovered Reservoirs

Location	Year Built	Capacity	Water Depth	Slopes Inside	Slopes Outside	Slab	Reinforcement	Expansion Joints	Total Cost	Cost Per Million Gals	Remarks
Everett, Wash.	1916	1,225,000	16'-0"	1½:1	2:1	6½"	Steel bars		$10,700	$8,750	
San Diego, Calif.	1920	3,500,000	10'-0"	1½:1	1½:1	3"		Asphalt	29,324	8,400	
Lewiston, Idaho	1923	3,600,000	20'-0"	1½:1	1½:1	4"&2" Membr	Steel bars	Asphalt	43,760	12,150	
Lewiston, Idaho	1923	4,000,000	20'-0"	1½:1	1½:1	4"&2" Membr	Steel bars	Asphalt	42,700	11,700	
Salt Lake City, Utah	1915	5,000,000	20'-0"	1:1	1:1	6"	Steel bars	None	20,177	4,035	
Salt Lake City, Utah	1900	5,000,000	17'-4"	1½:1	1½:1	8"&10"		Asphalt	47,000	9,400	
Port Angeles, Wash.	1924	6,000,000	20'-0"	1½:1	2:1		Steel bars	Asphalt	64,000	10,665	
Boulder, Colorado	1922	8,000,000	26'-0"	1½:1	2:1	5"	Steel bars	Asphalt	59,500	7,440	
Everett, Wash.	1916	10,000,000	20'-0"	1½:1	2:1	8"	Steel bars	Asphalt	80,000	8,000	
Salt Lake City, Utah	1922 1924	10,000,000	30'-0"	1½:1	1½:1	6"	Steel bars	Asphalt	50,474	5,047	
Salt Lake City, Utah	1915	10,000,000	30'-0"	1:1	1½:1	6"	Wire mesh	Asphalt	45,774	4,577	
Grand Junction, Colo.	1923	13,500,000	20'-0"	1½:1	2:1	Sides 6" Floor 5"	Steel bars	Asphalt	74,000	5,480	Side lining - 2 course and membrane
Portland, Oregon	1911	49,000,000	31'-0"	2:1	2:1	5"to9½"		Membrane over Asphalt	508,561	10,378	Twin Reservoir
Flagstaff, Ariz.	1925	50,000,000	35'-0"	2:1	1½:1	Sides 4½" Floor 4"	Steel bars & mesh	Asphalt	235,000	4,700	Side lining - 3" concrete - membrane and 12" gunite
Portland, Oregon	1911	76,000,000	21'-0"	2:1	2:1	5"-8"		Asphalt	547,890	7,209	Twin Reservoir
Walla Walla Wash	1923	15,000,000	20'-0"	1½:1	2:1	7"	2 layers Wire Mesh	Copper & Asp	251,764	16,900	Twin Reservoir Earth Emb. center wall
Fort Bragg Calif.	1912	2-1,500,000	8'6"	3:1	1½:1	None	No lining		4677	1,560	Clay embankmt. Excav. 5' deep

Table III—Masonry Walls, Covered Reservoirs

Location	Year Built	Capacity	Depth	Type	Floor Slab	Roof	Total Cost	Cost Per Million Gals.	Remarks
Russell, Kans.	1910	80,000	15'-0"	Ring Tension	6"	3½" Conc. Slab & Beam	$ 3,100.	$ 38,800	
Upland, Calif.	1925	200,000	14'0"	Ring Tension	4"	Wood	3,000	15,000	Roof - Wood on conc. columns
Junction City, Kans.	1924	200,000	13'3"	Ring Tension		Concrete	7,000	35,000	15" Earth cover over conc. roof
Mt. Pleasant, Iowa	1914	205,000	12'0"	Ring Tension	8"	4" Concrete	4,150	20,000	
Santa Ana, Calif.	1926	250,000	18'0"		6"	Concrete	4,700	18,800	
Whittier, Calif.	1926	300,000	10'-0"		4½"	Wood	5,800	19,350	
Kearney, Nebr.	1924	1,000,000		Ring Tension		Concrete	15,000	15,000	
Livingston, Mont.	1917	1,000,000	13'0"	Ring Tension	8"	6" Concrete	27,507	27,507	High labor & material costs
Junction City, Kans.	1917	1,000,000	16'0"	Ring Tension	8"	4" Concrete	12,893	12,893	
Hibbing, Minn.	1914	1,000,000		Ring Tension			17,082	17,082	
Mishawaka, Ind.	1923	1,500,000		Ring Tension		Flat slab concrete	31,358	21,000	Heavy Floor designed against up water pr.
Rapid City, S.D.	1923	2,000,000		Ring Tension					
Ponca City, Okla.	1925	2,000,000	14'6"	Ring Tension	6½"	Flat slab concrete	36,485	18,242	Two tennis courts on roof
Independence, Mo.		2,000,000	20'0"		6"	Flat slab concrete			
Ft. Dodge, Iowa	1912	2,000,000	13'6"	Buttress	8"	3½" Concrete	24,800	12,400	
Arkansas City, Kans.	1920	2,000,000	14'0"	Ring Tension		5" Concrete	53,940	26,970	Two Tennis courts on roof
Del Mar, Calif.	1930	2,000,000	18'6"	Ring Tension	6"	Shake Roof	27,129	13,560	
Mishawaka, Ind.	1928	3,000,000	19'0"	Ring Tension	6"	8½" Concrete	55,555	27,777	2' Earth cover over conc. slab
South Bend, Ind.	1911	5,500,000	20'0"	Buttress	8"	6" Slab	61,700	9,400	Low labor & material costs in 1911
San Diego, Calif.	1909	17,000,000	19'0"	Cantilever	4"	Wood on Concrete Cols.	136,000	8,000	
Cedar Rapids, Iowa		8,000,000				Concrete	112,000	14,000	
Ventura, Calif.	1928	9,000,000	19'10"	½ Emb. & ½ St. Wall	2½" Conc.	Concrete	140,922	15,658	Special concrete roof truss construction
MASONRY WALLS - UNCOVERED RESERVOIRS									
Beaumont, Texas	1914	1,000,000	20'0"	Buttress	6"	None	26,500	26,500	Center wall
Ft. Madison, Iowa	1917	1,000,000	16'6"	Ring Tension	8"	None	9,500	9,500	
Tucson, Ariz.	1921	1,609,000	12'2"	Ring Tension	8"	None	36,400	22,700	
Winfield, Kans.	1917	1,750,000	21'0"	Ring Tension	4"	None	16,700	9,600	Consted on old res'voir floor & site
Leavenworth, Kans.	1914	5,500,000	20'0"	Masonry	3"	None	45,000	8,250	Masonry walls and puddle clay

dale, Calif. A mastic joint 6 in. deep and approximately ½ to ¾ in. wide, showed water percolation through the joint within a few minutes under 10 to 15 ft. head of water. The same joint, protected with treated fabric strips showed no percolations for heads up to 150 ft. However, when a small puncture was made in the fabric, percolation appeared within a few minutes. The joints with metal water stops were watertight under 150 ft. heads.

The mastic joint is usually cheaper and more easily constructed, and can be used successfully, when properly made, for water heads up to 20 ft. where absolute water tightness is not essential, but where water tightness is essential, a metal water stop is recommended.

Waterproofing. — Various admixtures or integral waterproofing materials in the form of a liquid, paste, or powder; surface penetration or surface coatings of bituminous compounds and the asphaltic or tar pitch impregnated membrane methods have been used in reservoir construction for waterproofing.

A dense mixture of concrete of approximately 1:2:4 proportions developing a strength of 2,000 lb. in 28 days, is practically impermeable to moderate heads of water. A 6-in. slab or wall of a well graded aggregate, properly placed, and puddled or compacted, should resist a head of 40 ft., and waterproofing mixtures or coatings are not necessary.

If, however, the damp concrete surfaces are to be exposed to freezing weather, then to prevent the spalling or disintegration of the surface, due to freezing, surface penetration or coatings of bituminous compounds are advisable. This may be termed damp proofing, rather than waterproofing.

Underdrains.—A well designed underdrainage system for an embankment type reservoir, and also for other types, may be a necessity to prevent damage or failure, and, in any case it is a good "telltale" indicator of leaks or a change in the conditions of the reservoir. The underdrains will prevent upward hydrostatic pressure on the floor and embankment slabs, due to unequal water levels in adjacent compartments, or on the underside of the lining slabs due to a high ground water plane when the reservoir is empty.

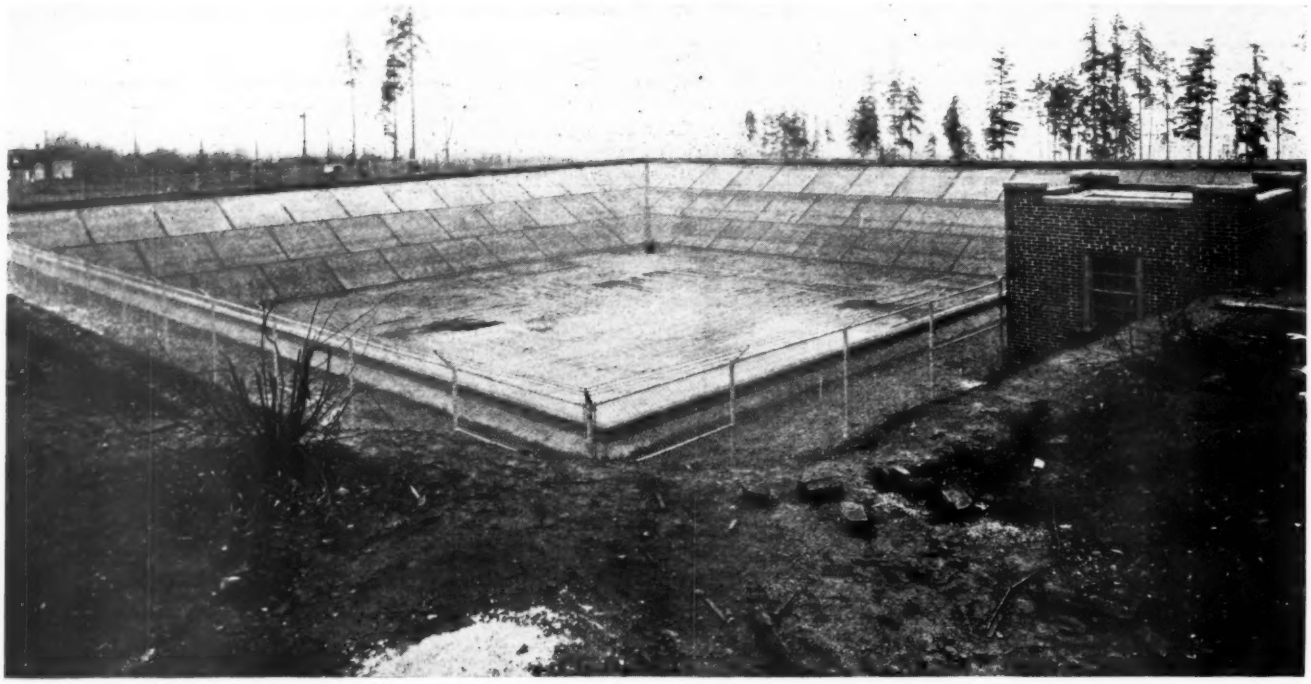
Any appreciable amount of water appearing in the under-drainage system outlet of a well designed and constructed reservoir calls for an inspection and study of its source and cause. Any appreciable increase in flow over a normal allowable amount at any time, is a warning that something has happened and an inspection and investigation of the cause and its remedy may save damage, if not possible disaster.

The soil conditions of the excavation and embankment, spacing of expansion or movement joints, height of embankment and other local considerations have their influences upon the design and layout of the underdrainage system. In large reservoirs it may be advisable to divide the drainage system into several units with separate outlets in order to more quickly locate the cause of excessive leakage that may appear from one section of the reservoir.

In general, the drain pipes should be located at the toe of slope where the side wall lining joins the floor, and also near and parallel to floor expansion joints, and, one or more lines across the face of high embankments.

The drains should be sewer pipe, or short lengths of cast iron soil pipe, laid with open joints in trenches backfilled with gravel up to the slab. If the soil is tight, the closer spacing of drains is necessary to allow lateral movement of water to enter the drains and a layer of several inches of gravel should be placed between the soil and lining to allow a porous medium for the water to readily percolate into the drains.

Storm Drainage and Overflow Provisions.—Frequently the reservoir location is in a canyon or ravine, and the reservoir construction may block the natural course of the surface waters arising in the drainage area



The 6,000,000 Gal. Earth Embankment, Concrete Lined Reservoir of Port Angeles, Wash.

above the reservoir. Ample provision should be made to prevent surface water from entering the reservoir and to provide waterways or conduits to bypass the storm water around the reservoir and protect the banks from wash or erosion. The capacity of such drains should be computed and designed for maximum intensity rainfalls on the drainage areas. Consideration should be given to the possibility of brush, stones or debris carried down by an excessive rainfall and blocking the waterway or opening thereto.

In some designs an additional provision is made for the emergency of an extreme cloudburst or the stoppage of the waterway, by providing an auxiliary overflow opening into the reservoir at a higher elevation with a similar outlet overflow opening in the wall connected to the waterway or drain at the down stream side of the reservoir. This lower spillway may be at the elevation of the normal water level when the reservoir is full and also serve as an overflow from the reservoir.

Costs.—Accessibility of site, amount and character of excavation and local costs of materials and labor are the main factors influencing the costs of construction. There may be many other factors also as the necessary appurtenances for diverting storm water, drainage, necessity or advisability for landscaping, beautifying the grounds, fencing, etc., that may add considerably to what may be termed average normal costs.

From statistics of actual construction costs, the cost per million gallons for embankment concrete lined reservoirs with wooden roofs, range as follows:

Capacity	500,000	to	1,000,000	gal.	$18,000	to $15,000	p.m.g.
Capacity	1,000,000	to	4,000,000	gal.	15,000	to 10,000	p.m.g.
Capacity	4,000,000	to	10,000,000	gal.	10,000	to 7,500	p.m.g.
Capacity	10,000,000	to	15,000,000	gal.	7,500	to 5,500	p.m.g.

Roofs of tar paper or patented roofing on wood sheeting with redwood or concrete columns, including column foundations, usually cost from 20 to 25 ct. per square foot of roof area.

In some cases for capacities up to 2,000,000 gal., a riveted plate steel reservoir may be purchased and erected at less cost than an earth embankment concrete lined or ring tension concrete wall reservoir, either with or without roof.

Acknowledgment.—The foregoing is an abstract of a paper presented Oct. 31 before the California Section of the American Water Works Association.

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State and Municipal Bond Election Results During 1930

New state and municipal bond issues authorized by the voters during 1930 totaled $626,059,337, according to The Daily Bond Buyer, of New York. This is a larger total than for any other year except 1928, when bond authorizations reached $783,412,085. Total for 1929 was $420,995,934; for 1927, $560,714,514; and for 1926, $625,673,058.

The total for the month of December was $10,461,100, representing the authorization of the voters of 76 municipalities in 26 States. Among the large projects approved were $1,200,000, Waukegan, Ill., North Shore Sanitary District; $1,750,000, San Antonio, Tex., Independent School District; $900,000, Pottsville, Pa., Sch. Dist.; $600,000, Roosevelt Irrigation Dist., Ariz., and $590,000, Cameron Co., Tex., Water Improvement Dist. No. 11.

The following table compiled by The Daily Bond Buyer, presents a comparison of bonds approved by months for the past three years:

	1930	1929	1928
		(.000 omitted)	
January	$ 11,620	$ 26,950	$ 14,140
February	17,861	13,309	8,204
March	33,741	22,154	21,636
April	45,325	37,963	77,465
May	56,823	61,852	136,989
June	13,414	53,711	45,609
July	14,628	35,895	59,211
August	3,369	16,540	22,010
September	8,590	85,308	16,870
October	4,136	21,760	12,096
November	405,976	48,499	345,933
December	10,461	17,002	23,244
Total	$626,059	$420,995	$783,412

Disaster Preparedness Plans for Water Works

Precautions That Should Be Taken When Designing and Constructing a Water Works in Places Subject to Earthquakes

By GEO. W. PRACY

Superintendent, City Distribution System, Water Department, San Francisco, Calif.

THESE precautions are concurred in by all who have had experience along these lines, the question of the extent of these precautions having to be decided in each case.

The first and most important is the making of a complete survey of the country to determine the extent, location and degree of activity of all earthquake faults. The necessary judgment must then be used to determine the degree to which the structures may be built over or adjacent to the faults. If it is necessary to build on or near the known fault lines the additional factor of safety and other precautions to be taken must be decided. The mere fact that a fault line passes through the dam site is not sufficient reason for its condemnation as is evidenced by the location of the Owyhee, Stony Brook and Roderiquiz dams.

Mr. S. B. Morris and C. E. Pearce have written an interesting article on the design of a non-overflow concrete gravity dam to resist earthquake.

Care should be taken to keep long supply lines on solid ground and away from fault lines.

The new 54-in. pipe laid from Lake San Andres to San Francisco was necessarily laid close to the San Andres fault line. To determine its exact location a study was made of the zones of varying intensity of the 1906 shock. Due to the character of the ground this intesity diminished for a certain distance from the fault line and then again increased. The line was laid in the zone of least disturbance. The outlet structure for this pipe consisted of a tunnel through the hill with a shaft, with the control gates, located near the lake. The short piece of tunnel from the shaft to the lake would, if carried through, as in normal construction, cross the fault line. To avoid this the tunnel was run to a point east of the fault and a large open cut made to bring the water across the fault to the tunnel. The slopes of this cut were made 5 to 1 to insure stability. In addition slots were left in the lake end of the tunnel structure so that a bulkhead could be placed and the tunnel unwatered. A heavy iron door, bolted on to form a water tight joint, gives entrance to the tunnel from the shaft.

At San Francisco it was found that some lines rigidly fastened to the pile structure were more badly damaged than other lines that were so constructed that the pipe could move from side to side independent of the motion of the trestle. In any city distributing system the main pipe lines should be on solid ground, the pipes in the filled portion of the city being so arranged that they can be easily shut off in case they are ruptured.

It has been suggested, but never put into effect, that the pipe systems in the filled ground be built as independent distributing units, being fed through two gates of proper size. This would enable these portions of the city system to be shut off very rapidly, preventing the draining of the reservoirs and leaving the undamaged portion in operation.

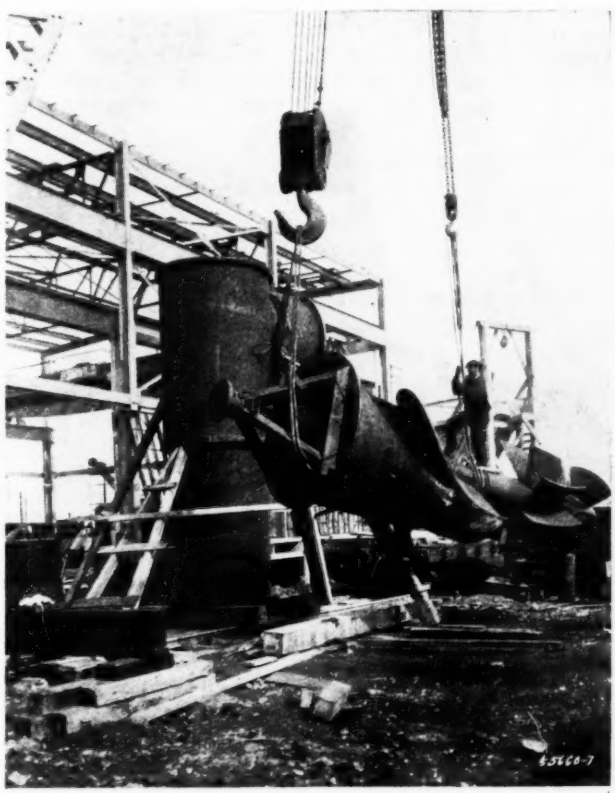
In the construction of the high pressure auxiliary water supply system built in San Francisco after the earthquake of 1906 a double spigot pipe, cast iron, with a sleeve joint was used in the filled ground on the assumption that the double lead joint would allow more freedom of motion without damage than would be possible with the regular bell and spigot joint. In the report recommending the construction of this system it was planned to so lay the mains that in the high building district the top of the mains would be not less than 5 ft. deep and in the outlying sections 3½ ft. deep. We have before noted that in Santa Barbara the top wall of a 3 story building fell and drove the pavement 3½ ft. into the ground. Mr. L. B. Cheminant (High Pressure Fire Protection in San Francisco, Bulletin of the Seismological Society of America) says that:

"All pipes were laid at a depth of at least 5 ft. to minimize danger of breaking by falling buildings."

Mr. Carl Wyant, resident engineer of the Montecite County Water District, which district is just adjacent to Santa Barbara has summed up his opinion as follows:

"Our distributing system consists of de Lavaud centrifugal cast iron pipe made with cement joints. After the Santa Barbara earthquake an inspection showed that our lines went through the shock without a leaky joint. The only trouble was in one place where a 12-in. pipe was broken due to a crack in the ground about 6 in. wide. Therefore, I think that cement joints are entirely satisfactory for earthquake conditions.

"I feel that wherever practical duplicate mains should be laid from the source of supply to the distribution system, and where



A Shell and Impeller of One of the Four Booster Pump Units, Each of 157,750 Gal. per Minute Capacity, Just Prior to Being Lowered for Installation in the Ford Motor Co.'s Rouge Plant New Water Tunnel Pump Well

this is not possible sufficient storage near at hand should be provided, to enable any possible repair sto be made. We have duplicate lines from our tunnel to the distributing system and have provided a line to make interchange with Santa Barbara possible. As you probably know our source of supply is partially from seepage water in a 2 mile tunnel and partially from a reservoir on the Santa Ynez River which is conducted through the tunnel to the coast side of the mountains. Santa Barbara has a similar situation. We feel that by tying the two systems together the danger from collapse of our tunnels is greatly reduced as they are about eight miles apart and pierce different formations.

"Together with Mr. Trace, I inspected the Santa Barbara tunnel after the earthquake and found that no damage had resulted. Our tunnel was under construction at the time, but our men happened to be at breakfast at the time of the first big shake, but they went right back in the tunnel and although we had shakes all that day they did not notice them at all. I am, therefore, of the opinion that unless a movement occurs on a fault which crosses a tunnel, that in solid rock the movement is reduced to a very rapid vibration and small throw and will cause no trouble.

"I feel that reservoirs should be placed on rock foundations wherever possible. Our small reservoirs were so situated and the shake had no apparent effect on them. In reinforced rectangular reservoirs I think it is well to tie the sides together in the center with a low reinforced wall. This also allows the reservoirs to remain in service while being cleaned out.

"My opinion is that on rock foundation a thin arched dam is very satisfactory in earthquake regions. This is based largely on the fine manner in which Gibralter Dam withstood the shake.

"On less solid foundations I believe that hydraulic fill dam will be most satisfactory. We have built one about 100 ft. high in this manner. In addition to the puddle core in the center we put a concrete cutoff wall at the upstream toe and lined the upstream face with 2-in. reinforced gunite divided into 24 ft. squares with copper expansion joints. I feel that this type of structure is much more flexible and consequently more earthquake proof than a rolled fill.

"I feel that no dam should be constructed without the services of a competent geologist, and of course since the new law the state engineers office will see that this is done.

"In places where pipe lines cross an active fault, I think it would be well to provide expansion joints on either side, and in remote locations, an extra length of pipe left for emergencies."

The San Jose Water Works, which supplies that city with water, largely pumped from wells by motor driven units, has constructed an emergency plant containing two 300 hp. gasoline engines direct connected to generators, the units being housed in a building which has been made as earthquake proof as possible. These units are of sufficient size to operate the main pumping station which is located alongside of the generating plant.

The personnel of a public utility should be so trained as to be able to act promptly and effectively in case of an accident. Fortunately, these emergencies usually affect only a portion of the system. A greater catastrophe would merely involve more stations and more men.

Both private and public telephone lines connect the main offices, the necessary men are on duty at all times, and automobiles are always available. Any changes from the normal operating condition should be immediately relayed to the nearest man in charge of the system. Only men possessing the necessary judgment should be placed in jobs requiring quick and independent action. These men should be encouraged to do their own thinking. Detailed action must depend upon the conditions met.

Acknowledgment—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

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A CORRECTION.—In the article on "Storm Standby Tanks" in the January issue line 14 in the second column of page 10 should have been "consumption is one-third that of North Toronto."

Rocky Mountain Water Works Men to Meet in October

By mail ballot the executive committee of the Rocky Mountain Section of the American Water Works Association voted to hold the 5th annual meeting of the section in October. The dates set are Oct. 21, 22 and 23, Wednesday, Thursday and Friday.

The fall meeting was definitely favored by a large majority of the section members voting by return postals. Out of the 31 votes thus cast, 11 favored October, 11 favored September, 2 February, 2 November, 1 April, and 4 indicated any time would be satisfactory. The executive committee then considered September and October, choosing the latter and the dates mentioned. Full consideration was given to the advantages of other dates requested by some members, but the dates chosen were found to favor the largest number.

The meeting will be in Denver this year as previously. The headquarters hotel has not yet been selected; this and other details of the program will be worked out by the program committee. Invitations and programs will be sent out two or three weeks in advance of the meeting.

The members of the program committee, appointed by the chairman, who will arrange the details of the 5th annual meeting, are:

Paul R. Revis, chairman, 102 City & County Bldg., Cheyenne, Wyo.

John H. Griffin, City Hall, Trinidad, Colo.

George J. Turre, 1509 Cleveland Place, Denver, Colo.

Ex-officio, L. C. Osborn, section chairman, Loveland, Colo., and Dana E. Kepner, section secretary-treasurer, 226 Continental Oil Bldg., Denver, Colo., will also serve on the program committee. All members are urged to send suggestions for this year's meeting to any of the above committee members.

The vote of the section members on the postals returned was practically unanimous in favor of some sort of a water works school. Many suggested having such a school in connection with the annual meeting. Some favored having the school, and the meeting in connection, in a different state of the section each year. For this year the matter will be turned over to the program committee and it is likely that the cooperation of the University of Colorado and the Colorado State Board of Health will be solicited for a 2-day school in connection with the meeting in October.

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Meeting of New York Sewage Works Association

For the third annual meeting of the New York State Sewage Works Association which will be held in Albany on March 5, the chairman of the program committee, R. C. Wheeler, has announced the tentative program:

9:00 A. M.—Registration.

10:00 A. M.—Business meeting.

11:30 A. M.—Technical paper. Lawrence H. Luther will discuss operation of the Freeport, Long Island, sewage treatment works. Ample time is allotted for discussion.

12:45 P. M.—A recess.

1:00 P. M.—Luncheon with special features.

3:00 P. M.—Symposium on sludge—digested and otherwise. There will be special papers on this subject with interesting discussion assured.

5:30 P. M.—Adjournment.

Water Softening and Purification Plant of Dundee, Mich.

New Installation Embodies Latest Development in Water Softening and Includes Use of Carbon for Removal of Tastes and Odors

By CARLETON S. FINKBEINER
Of George Champe and Associates, Consulting Engineers, Toledo, O.

THE Village of Dundee is located in Monroe County, Michigan, about 25 miles northerly of Toledo. The River Raisin flows through the center of the village. It has a drainage area of 600 square miles upstream, and empties into Lake Erie at Monroe, Mich., some 14 miles to the east. The river is the outlet for several springfed lakes. The minimum flow of the stream is several times the estimated maximum water requirements of Dundee in 1960. An old 8 ft. concrete impounding dam located in the River Raisin about the center of the village provides storage.

Original Water Works System.—The original water works system for Dundee was constructed in 1917 with a deep well source of supply. As this water showed evidences of yellow sulphur, the 150,000 gal. concrete reservoir was equipped with a tray type coke aerator. An elevated tank and tower of 50,000 gal. capacity was a part of the original system. After a few years of operation the well water turned from yellow to black sulphur with an intense odor of hydrogen sulphide. Test wells sunk in other parts of the village yielded water of no better quality, thus confirming the advice of state geologists. On December 16, 1929, the voters of the village approved a bond issue to construct a water purification plant. The general contract for the plant was awarded to Bever and Morris, Inc., Cleveland, O., on May 29, 1930.

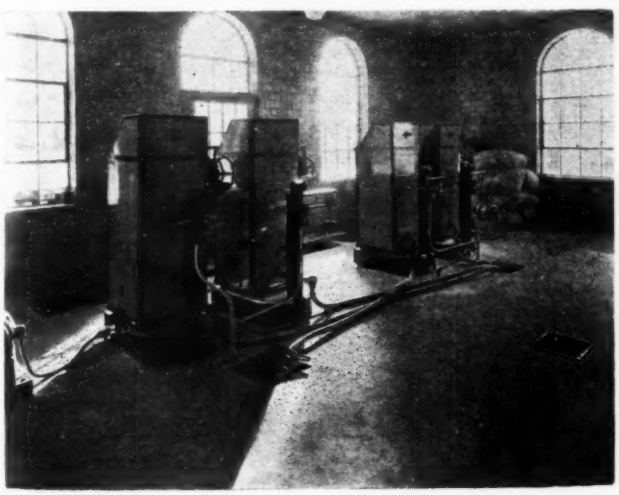
Character of Water From River Raisin.—Analyses extending over a period of one year showed that the water from the River Raisin contains over 1 part per million of Fe_2O_3; has a total hardness averaging about 300 parts per million with a bicarbonate hardness of about 250 parts per million; and at times has a high oxygen consumed and volatile organic material value. These last two conditions are in great part due to the industrial wastes from a beet sugar factory located about 15 miles upstream from Dundee. In view of the large amount of bicarbonate hardness present in the hard river water it was decided to make the new purification plant a softening plant. Careful consideration of the problem presented by the beet waste refuse, which would undoubtedly produce tastes and odors, finally determined that activated carbon treatment should be included in the processes.

The New Plant.—Because of the limited amount of money available for construction of the new plant it was necessary to design as compact a layout as possible with a capacity of 600,000 gal. per day. The plant consists of a single story and basement building with the settling basins and carbonation chambers immediately adjoining. The construction is of reinforced concrete to the foundation line with a face brick exterior above on the building. Duplicate sets of mixing tanks, settling basins, carbonation chambers, filters, pumps, and dry chemical feeders are provided for flexibility of operation. Theoretical retention periods with the plant operating at its full capacity are as follows:

Each mixing tank	20 minutes
Each settling basin	120 minutes
Each carbonation chamber	10 minutes

It is also possible to operate the plant at half its rated capacity thereby doubling the retention periods above. Cross connections are provided so that operation may be in series or in parallel or in series parallel, and if necessary the flow can be reversed through the settling tanks with only single carbonation.

The two low lift pumps are of the horizontal centrifugal type and take their suction from a concrete intake well, equipped with screens, located on the river bank. A cast iron intake line is laid from the intake well to deep water in the river channel. The water is forced under a 12 ft. head into the bottom of either or both



Chemical Storage and Feeding Room

Operating Room

Front of Water Softening and Purification Plant

mixing tanks where the chemicals are added from a battery of 4 Omega dry chemical feeders. Solution hoses extend from the solution pots of the platform scale equipped feeders into downtakes situated in the mixing tanks at the point of entry of the raw water. The water, entering the bottom of the mixing tanks, rises and flows out through the take off troughs on the opposite sides of the tanks. Agitation is provided by fixed position double paddles direct connected through a shaft and speed reducer to electric motors. Very satisfactory agitation is being furnished by these units.

Flowing from the mixing tank to the settling basin the water is conducted to a central stilling well in the basin, descends to the bottom and rises to a trough with weir plates extending around the entire periphery of the basin. For appearance and economy the settling basins were made octagonal in shape. Settling tanks are of the flat bottom type and are provided with sludge removal piping covering the bottom with quick opening valves at the outlets. Sludge removal is accomplished by hydraulic pressure. Flow may be either to the other settling basin or to the first of the carbonation chambers. In the former case the water is conducted to the central stilling well in the basin and in the latter case through a downtake to the bottom of the carbonation chamber from where it rises to the outlet pipe on the opposite side and enters the building. Carbonation chambers have an ordinary pipe grid in their bottoms for distribution of the gas. The gas is produced by burning artificial gas in a small stove (also equipped for coke). A Nash Hytor compressor takes its suction through the stove and a scrubber and forces the gas into the water.

Entering the main building the water is visible in two collecting sumps and can now be conducted to the filters or returned to the second mixing tank. Filters are filled with 24 in. of gravel from 2½ in. to 1/12 in. in size and 30 in. of sand having an effective size of .405 m.m. and a uniformity coefficient of 1.45. The bottom 3 in. of sand has an effective size of .8 m.m. Laterals are of wrought iron and are not provided with strainers. Loss of head gauges, controllers, and a wash water line manometer are appurtenances of the filters. There is a connection to the manometer from an orifice plate in the discharge line of the low lift raw water pumps. On the discharge line of the plant there is an oriflow type register, indicator, recorder.

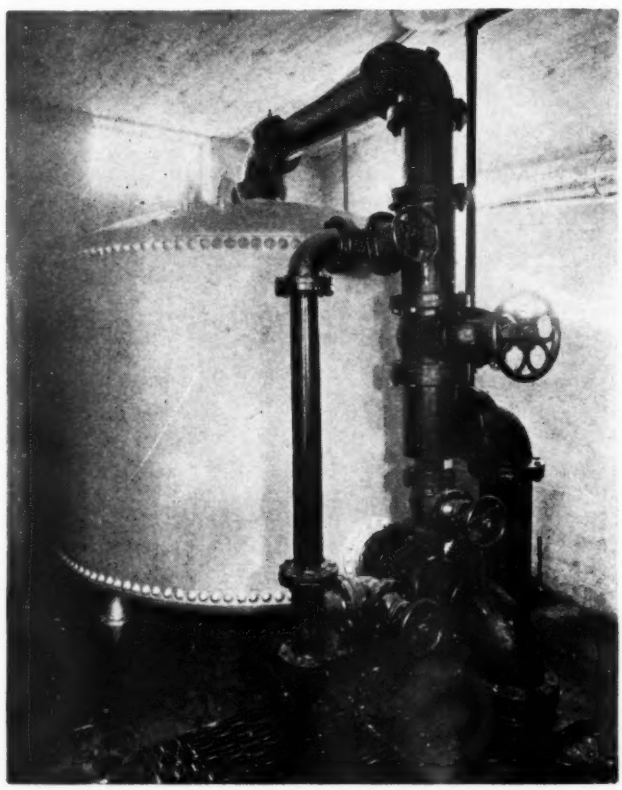
A clear well of small capacity is situated below the filters, into which the filtered effluent flows through a common manifold outlet of the controllers. Chlorine is applied from a dry feed chlorinator into this manifold but it may be applied at other points in the treatment.

As the activated carbon treatment was designed to be used for not over 3 months of the year it was decided to make it a pressure unit or adsorber. An International Filter Company "Hydrodarco" unit was installed. At full plant capacity the adsorber would be operating at a 10 gal. per square foot per minute rate but it is only intended to operate the plant at half its capacity for several years. When it is necessary for the plant to function at its rated capacity and to use the adsorber it is possible to split the treatment so that a portion of the water would be pumped to the village without carbon treatment but the greater portion with it. The piping and valves are arranged so that the adsorber which normally operates on upward flow can be washed in the reverse direction and also so that it can be cut out of the discharge line, partially or entirely.

Water Treatment.—The treatment that is being given the water with the present clear raw water (due to the drought) is as follows:

Treat the water with lime to about 25 parts causticity through Number 1 settling basin, carbonate in Number 1 carbonation chamber reducing the causticity to 0 parts, add alum in Number 2 mixing tank sufficient to get a fine floc in number two settling basin, carbonate in Number 2 carbonation chamber to neutrality and filter. In flood time it is intended to apply a heavier dosage of alum in Number 1 mixing tank and apply the lime in Number 2 mixing tank. If necessary the sludge return to Number 2 mixing tank can also be operated, as a sludge pump is provided to pump sludge from the sludge sump to Number 2 mixing tank. Provision is made for feeding soda ash but it seems unlikely that it will be necessary. About 0.1 parts of chlorine is added to the filter effluent.

This treatment represents the latest development in water softening and is being practiced at only a very few water plants in the United States. Its effective-



Activated Carbon Filter or Adsorber

ness was clearly shown at the Dundee plant which was operated experimentally for a few days with double settling but with only single carbonation, both lime and alum being added in Number 1 mixing tank. After the treatment was changed to that above outlined a marked improvement was noted in the appearance and characteristics of the filter effluent. Preliminary investigation has also shown an economy in operating costs. When the plant started operation on Dec. 3, 1930, the filter effiuent showed a quite pronounced sweetish taste and odor, due to the beet sugar plant washings. This taste and odor would surely have been the cause of much complaint from the water customers. The activated carbon adsorber was then put in operation and no tastes or odors have since been noted. It, therefore, appears that the unit is performing as was anticipated and that its services will be invaluable. Data in regard to the operation of this unit will be available in a few months as careful check is being made on its performance.

The writer wishes to acknowledge the suggestions and advice given by Charles P. Hoover who assisted in the design and operation of this plant. Particularly in regard to the use of the activated carbon adsorber were his suggestions highly valuable.

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Recent Court Decision on Water Supply Pollution

An interesting decision on the prevention of pollution of a stream used for domestic water supply purposes was handed down on Oct. 10, 1930, by the Utah Supreme Court in the case of Bountiful City, Utah v. DeLuca, et al. (292 P. 194). Public Health Reports of Dec. 12, 1930, comments on the case as follows:

An action was brought by Bountiful City to restrain the defendants from keeping or grazing goats or other livestock within 300 ft. on either side of a certain creek, its tributaries, or sources of supply, some of the waters of which were used by the city and its inhabitants for culinary and domestic purposes, and from permitting such animals to drink out of such creek, its tributaries, or sources of supply, and from in any manner contaminating such waters.

United States statutes, cities of the class of Bountiful City were authorized to construct waterworks within or without their corporate limits, and, for the purpose of maintaining and protecting the same from injury or pollution, their jurisdiction was extended over the territory occupied by such works and over all reservoirs, streams, etc., used in and necessary for the maintenance and operation of such works and over streams and sources from which the water was taken, for 15 miles above the point from which it was taken and for a distance of 300 ft. on each side of the stream. Authority was given to enact ordinances and regulations necessary to carry the conferred powers into effect and to prevent pollution of streams from which the inhabitants of the cities derived their water supply. Bountiful City passed an ordinance which defined the watershed area of the city as the entire area in any canyon above the intake of the city within which water drained into any stream or tributary thereof where such stream was taken by the city into its waterworks system for culinary and domestic purposes. The ordinance made it unlawful for any person to permit any loose cattle, horses, sheep, or other animals to run at large, except where such livestock were more than 300 ft. from any stream or source of water supply within the watershed area, or to permit animals to water directly from the stream or to remain in or near or to pollute such stream.

In the instant case the creek involved flowed through the lands of the defendants. Such lands were suitable only for grazing purposes and were not capable of being used for any other purpose. The defendants used their lands for grazing from 300 to 500 goats and were engaged in selling goat's milk and manufacturing cheese and other products from goat's milk.

The judgment of the trial court was in favor of the city, and the defendants appealed. The supreme court stated that the proper disposition of the case involved the question of whether the statute, ordinance, and decree amounted to a taking or deprivation of property without compensation or due process of law. The court came to the conclusion that neither the statute nor the ordinance was "an unreasonable regulation when properly and reasonably applied and enforced." But with respect to the decree, the court's finding was as follows:

> Thus, in so far as the decree restrains the defendants from corralling or bedding or holding their goats or other livestock within the 300-ft. limit above the intake of the city, from suffering or permitting any dead animals to be in or near the creek or any tributary thereof whether within the 300-ft. limit or beyond it, from in any manner unnecessarily or unreasonably or negligently so using their premises as to cause dung from animals or other refuse to be cast or washed into the creek and which in the exercise of all reasonable care and caution may be avoided or prevented, from suffering or permitting any of their animals above the city's intake to drink directly from the creek or any of its sources of supply, and which in the exercise of all reasonable care and caution may be avoided and prevented, and from in any manner polluting or contaminating any of the waters of the creek or of any of its sources of supply, which, in the making of a proper, reasonable, and necessary use of the lands, and in the exercise of all reasonable care and caution may be avoided and prevented, the judgment is affirmed. In so far as the decree, without compensation, restrains the defendants from grazing their lands within the 300-ft. limit under any and all circumstances, though in so doing the defendants do not make any unreasonable, unnecessary, or negligent use of their lands and use all reasonable care and caution to avoid or prevent any pollution or contamination of the waters of the creek or of any of its sources of supply, the judgment is reversed.
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Longest European Water Tunnel Completed by Amercan Engineers

The holing through of the Boyati Tunnel, near Athens, Greece, said to be the longest hydraulic tunnel in Europe, was accomplished by the American Engineering firm of Ulen & Company on Feb. 9. This tunnel is one of the important links of the $11,000,000 Athens water supply system which was started in 1925, and which will be entirely completed within the next few months, thus assuring the city of an adequate water supply for the first time in over 3,000 years.

The Boyati Tunnel is bored through the Parnes mountains and is 8½ miles long. The engineers have also utilized a section of the aqueduct built by the Roman Emperor Hadrian in 130 A. D. and which until 1926 was the only substantial source of water supply for Athens. The engineers also reported recently that Marathon Lake created by the marble-faced Marathon Dam had overflowed, indicating that over 11 billion gallons of water is impounded.

Ulen & Co. also have a joint contract with the Bank of Athens to manage the water supply for a period of 25 years and for this purpose have organized the "Societe Anonyme Hellenique des Eaux des Villes d'Athens, Piree et Environs."

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by A. ELLIOTT KIMBERLY, Associate Editor
Consulting Sanitary Engineer, Columbus, O.

Milk Waste Treatment Practice

Milk waste may be defined as a mixture of milk solids and butter fat losses, spills, unrecovered byproducts and cleansing, disinfecting and process chemicals, diluted in varying proportions with cold or hot water, from washing, condensing and cooling operations.

Frequently, at country factories of the milk industry and at times at city factories sewered to municipal sewerage systems where sewage treatment plants are in operation, to prevent nuisance in the smaller rural streams and interference with municipal sewage treatment plant operation, respectively, it becomes necessary to process these wastes. The degree of treatment required varies widely, depending upon a variety of conditions and details not only of the type of treatment, but also of the type of plant corresponding to any specific treatment procedure, depend upon the character of the raw material mtake and in particular, upon the disposition of byproducts.

Studies and Research Work.—Beginning in 1923, milk waste treatment began to receive considerable attention and research work began notably at the Agricultural Experiment Station of Cornell University, at Ithaca, N. Y., (1) at Iowa State College, Ames, Ia., (2) and at the State Department of Health of Maryland (3).

The Iowa studies under Max Levine (4, 5, 6, 7) were continued through 1929 and have resulted in the publishing of five very important and instructive bulletins, which have markedly advanced knowledge in the art of milk waste treatment by bacterial agencies.

Further studies were made by the industry itself in Ohio and Michigan (8, 9), and the State Departments of Health of Minnesota, Wisconsin and Texas, each attacking the problem from a different angle, but generally continuing and expanding on a factory or testing station scale, the work of previous investigators.

The work in Ohio, began in 1926 and continued for about three years and was undertaken by a Waste Disposal Committee of the Ohio Dairy Products Association, at the suggestion of the Ohio Department of Health. The committee made a practical study of the problem under the guidance of a sanitary engineer and in addition to the construction and operation of several full scale treatment plants at factories where nuisances from stream pollution were acute, accumulated a mass of practical information, particularly correlating processes of milk waste treatment to factory operation, showing in particular the wide variation in the composition of milk wastes, depending upon intake material, factory housekeeping, and byproduct disposition.

Most important of all, perhaps, these studies under industry auspices, brought out the very important fact, suggested by an executive of the industry, that not the volume of waste, but the pounds of milk solids therein, should be the basis of waste treatment plant design.

Flow of Receiving Stream in Relation to Factory Intake.—The necessity in many instances for processing milk wastes, is due to the fact that the summer flow in the receiving stream is too limited to prevent the development of nuisances and the destruction of fish life. The required stream flow for a given intake, may be closely estimated from fairly recently developed data.

It has been determined that there is a definite relation between milk solids not fat and 5-day B.O.D. or Biological Oxygen Demand. For fluid milk, this ratio is tentatively 1.1. Let there be assumed, a fluid milk intake of 40,000 lb. and a loss of 1.5 per cent or 600 lb. At 12.5 per cent milk solids, the loss is 75 lb. of milk solids per day or $75 \times 1.1 = 82.5$ lb. of demanded oxygen.

Assuming oxygen saturation in a stream at a temperature of say, 25.0 deg. C., a flow at the rate of 1.547 sec. ft., or 1,000,000 gal. in 24 hours, will supply 69.3 lb. of oxygen. Merely to furnish the oxygen required to satisfy the milk solids demand, means a stream flow of 1.83 sec. ft. or approximately 1,268 g.p.m. Including the minimum of 3.0 p.p.m. of dissolved oxygen necessary to support major fish life, demands a total stream flow for the wastes from the assumed 40,000-lb. daily fluid milk intake, of 2.38 sec. ft. or 1,540,000 gal. in 24 hours.

It will be clear from the foregoing, why the problem of milk waste treatment arises, especially in the case of country factories, so frequently located on streams of small drainage area.

Available Methods of Waste Treatment.—Current practice in milk waste treatment, with respect to the partial or complete removal of milk solids is indicated **in Table I:**

Composition of Milk Waste in Relation to Treatment.—If whey is eliminated, where cheese or casein is manufactured, partial treatment processes as above, are independent of the character of the waste. Complete treatment processes however, are materially affected by the pH and suspended matter in the wastes and upon its concentration, that is, its BOD or Biochemical Oxygen Demand. No complete treatment can handle excess

Table I—Current Partial or Complete Milk Waste Treatment Practice

Partial Treatment
- (a) Septic tanks
- (b) Chemicals
  1. Sulphuric acid-aluminum sulphate-sulphate of iron

Complete Treatment
- (a) Sand filters
- (b) Trickling filters
- (c) Broad irrigation, with odor control by chlorine.

Excerpts from an address delivered Oct. 23, 1930, before the Second annual Dairy Engineering meeting, of the American Society of Agricultural Engineers, Cleveland, O.

skimmilk, skimmilk spills, buttermilk in appreciable quantities or first churn washings and buttermilk spills, unless curd separation is included in the treatment program.

Ordinarily, it is essential as the first step in providing for waste treatment, that there be a separation of all cooling and condensing water.

Modern methods of milk waste treatment by bacterial processes, completely discard the septic tank as antecedent thereto, since reduction of the pH, materially below the neutral point, has an adverse effect upon the bacteria, which oxydizing processes utilize for the conversion of the milk solids and lactose to simpler forms.

If fresh milk wastes are applied in relatively thin films, to filters constructed of coarse, rough, resistant material, from 7 to 10 ft. deep, so that a plentiful supply of oxygen is always present within the filtering material, it is possible, at practical rates of treatment, to remove a very substantial proportion of the milk solids, including lactose.

The degree of modification, furthermore, depends upon the concentration of the waste in terms of units of pollution, namely, 5-day BOD or Biochemical Oxygen Demand and it is preferable that the raw wastes contain not to exceed from 800 to 1,000 p.p.m. It is obvious that to secure a waste as dilute as the above, requires not only special attention in factory operation, to prevent spills and in general, raw material drips and first rinsings, from entering the drains, for example by catching in cans, but also, the admission of a definite proportion of clear water from coolers or ice machines.

The necessity for preventing the development of acidity, requires that the waste be as free as possible from suspended matters and that velocities be maintained sufficiently high to prevent suspended matter deposition and subsequent souring, followed by putrefaction. At practically all types of factories, except creameries, powder plants and others where driers are used, it is ordinarily possible, satisfactorily to cope with the suspended matter in the waste, although its presence necessitates more frequent cleaning of storage tanks, than would be the case, were the organic matters in the wastes almost entirely in solution.

It follows, therefore, that in creameries in particular, provisions must be made for the separation of the buttermilk curd, unless the disposal of buttermilk and particularly the method of its removal from the churn, together with the first churn rinsings, is so carried out that none of the buttermilk in the first churn rinsing can reach the drains.

It is evident that the curd so recovered, can be returned for admixture with the buttermilk stored in the souring tanks where semi-solid is produced or to the storage tanks ahead of the buttermilk drier. It is however, quite practical so to arrange the suction of the buttermilk pump, that all of the buttermilk, including that in the first churn rinsings is prevented from entering the drains which carry the normal factory wastes.

Originally pointed out by the Michigan State Department of Health and later confirmed by work in Ohio, the important practical conclusion has been reached that at condensories, under careful pan operation and particularly with pans of the latest design, entrainment losses are so slight that the BOD of the pan water is sufficiently low to permit its direct discharge into a receiving stream.

It is furthermore evident that pan water is often advantageously a diluent for the effluent of a treatment plant, serving thus to assist the receiving stream, at least during the hours of pan operation.

In concluding this discussion on the relation of the composition of milk wastes to modern oxidizing treatment processes, it seems unnecessary again to emphasize that the valuable by-products such as skimmilk and buttermilk must be excluded, together with whey, if any, in all cases where conditions necessitate waste treatment.

To illustrate the application of modern milk waste treatment in practice, three typical cases are presented, one representing partial treatment with chemicals, and the use of trickling filters and sand filters, respectively, for situations where substantially complete effluent stability is required.

Partial Treatment by Chemicals.—In an important and interesting bulletin, issued by the Agricultural and Mechanical College of Texas, on May 1, 1930 (11), instructive data are presented showing the results of the treatment of milk wastes with sulphuric acid, ferrous sulphate and sulphate of alumina, respectively. These studies stress the fact that an increase in the pH by the use of alkalies, even in conjunction with ferrous sulphate or sulphate of alumina, is distinctly detrimental to best results and on the contrary only such chemicals should be used as will reduce the pH to the point of casein separation, which is at approximately pH 5.4 to 4.8.

It was found during these studies that chemical treatment can be expected to produce a clear effluent, with a reduction in the biochemical oxygen demand of approximately 80 per cent. This result can be obtained with any of the three chemicals above mentioned. It is accomplished by sulphate of alumina, when applied to 0.5, 1.0 and 2.0 per cent waste on the basis of using 1.5, 2.5 and 3.3 grains per gal. respectively.

An Ohio milk factory was recently confronted with the problem of providing as a temporary expedient, at least, some process, low in first cost, that would effect a very substantial removal of organic matters from the wastes, but not necessarily sufficient to produce a completely stable effluent. This factory has a daily flush intake of about 40,000 lb. of fluid milk, about 2,250 lb. of sweet cream and 840 lb. of sour cream, and ships cream to one of its branches.

After securing the basic designing data, treatment with sulphate of alumina was recommended using an existing chemical precipitation tank, dry feeding equipment and float switch controlled centrifugal pump, set within an existing pump well.

Pan water and all cooling and condensing water were piped to a separate outlet.

The existing plant includes a pump well of about 150 gal. capacity, a float switch controlled centrifugal pump of 25 g.p.m. rated capacity, a Gauntt dry feeding machine, reduced through suitable shafting to a low r.p.m. and a partitioned concrete settling tank, approximately 10 ft. square in plan and 10 ft. deep of sufficient capacity to retain the entire waste flow of each working day (about 7,000 gal.) and a sludge pump discharging into an old churn, erected on a truck. The settling tank is so arranged that about 80 per cent of the supernatant liquor may be drawn off to the creek. The remaining 20 per cent, as sludge, is pumped to the sludge tank and hauled away to a convenient point of disposal.

This plant operated through the dry summer and fall months of 1930 with very satisfactory results. The quantity of sulphate of alumina applied is in the vicinity of 7.5 grains per gal., reducing the pH of the raw waste to about pH 4.6. Sulphate of alumina

ground, in barrels FOB the factory, LCL, costs about 2 cents per pound and at this factory the daily consumption is about 28.5 pounds or a cost for chemicals of approximately 1.6 cents per day per 1,000 pounds of fluid milk intake.

Indicative of the results accomplished note the data in Table II which shows the character of the treated wastes. For comparison, the analysis of a composite sample of the raw waste, collected some months earlier, is included, but since the samples do not correspond, statements as to the degree of removal of the different constituents, are not feasible.

The volume of sludge produced at this factory daily, is about 2.12 cu. yd. for a fluid milk intake of 30,000 lb. Its cartage has not proved expensive and by its systematic removal and through intelligent operation this factory passed through a very dry summer and fall with practically no criticism as to its waste on the part of riparian owners below the plant. It should furthermore be stated that, the flow of the stream was substantially zero.

Complete Treatment by Trickling Filters.—One of the factory scale trickling filter plants constructed in Ohio during the industry's study of the milk waste disposal problem, is located at the Golden Star Dairy Co., near East Liverpool, O.

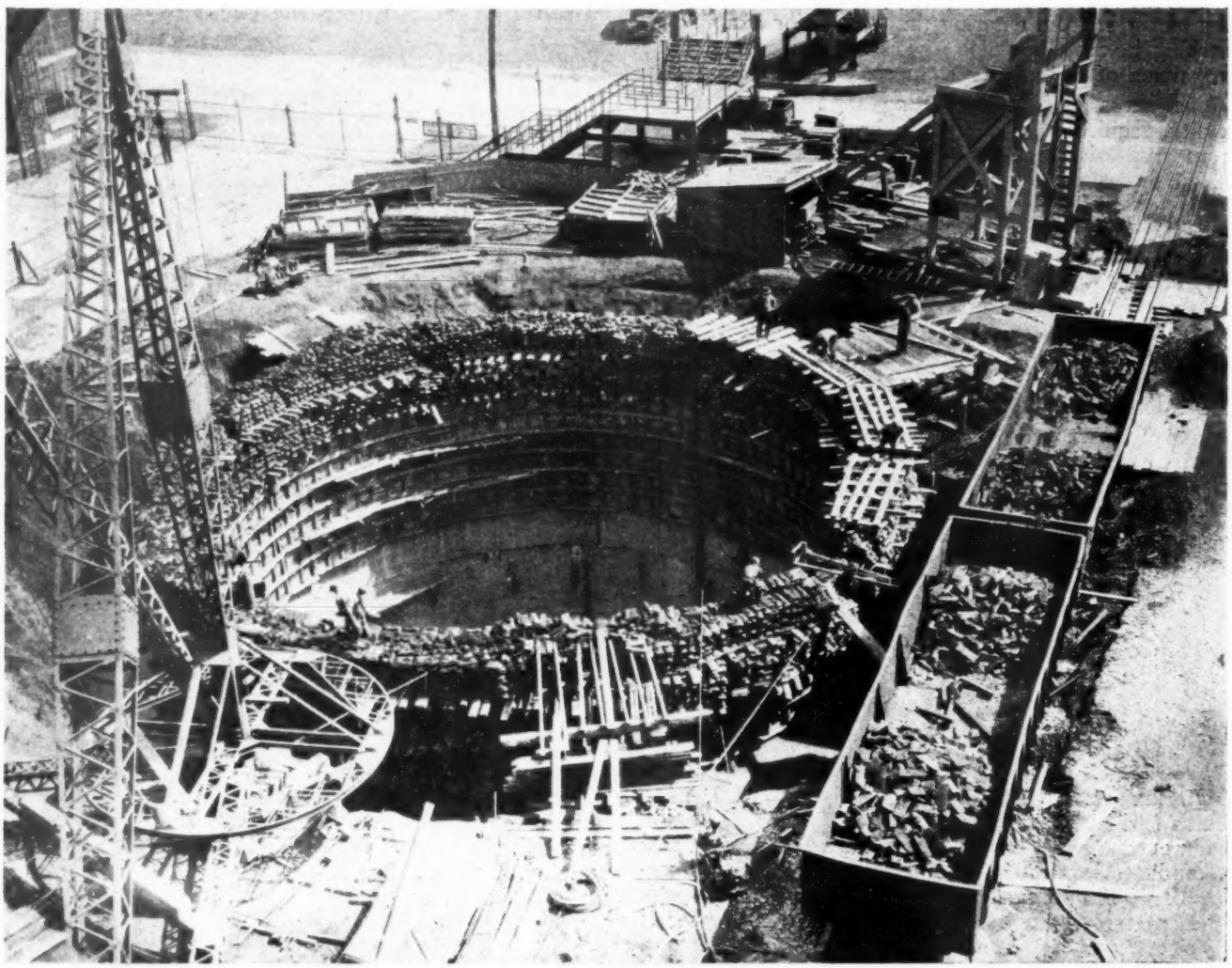
TABLE II—Analytical Data Illustrative of Milk Waste Treatment by Sulphate of Alumina
(Parts per million)

	Raw Waste*	Chemically Treated Supernatant
Date of collection (1930) March 11	.....	July 17
Total solids	1,780	836
Volatile solids	1,128	236
Nitrogen as free ammonia	1.6	1.5
Organic	31.2	4.2
Total	32.8	5.7
Total alkalinity	515	105
pH	9.1	4.6
Chloride	21	20
Permanganate oxygen cons.	260	60
5-day BOD	683	156

*Composite sample.

The Golden Star Dairy Co. maintains a bottling plant and at times manufactures butter. The flush intake of fluid milk is about 13,600 lb. As an initial step, all condensing and cooling water was removed from the waste drains.

The plant comprises a small sump or pump well, an automatic float switch controlled centrifugal pump, a force main, an elevated storage tank with controlled outflow, a slag trickling filter and a secondary settling basin. The settled effluent is pumped to an irrigation



Sinking the Pump Well for the New Water Supply for the Rouge Plant of the Ford Motor Co. The Cutting Nose Struck Hardpan at a Depth of 80 Ft. The Illustration Shows How 1200 Tons of Pig Iron Was Distributed Around the Top of the Uppermost Ring to Test the Strength of the Hardpan

area which drains to a local creek of very limited flow.

The fresh wastes are pumped to the storage tank which is drained completely each day, thence through orifice box control to the trickling filter.

The trickling filter is 12 ft. 2 in. x 31 ft. 4 in. in plan, inside dimensions and is 10 ft. deep. The filtering material is blast furnace slag, ranging in size from 1½ to 2¾ in. The slag is retained within walls constructed of reinforced concrete for the lower 2 ft. and extending below the frost line. Above this wall, the sides of the filter are formed of standard cement building blocks, laid up with cement mortar. Joints are tight in a horizontal plane and also in a vertical plane to within 6 ft. of the surface of the slag, but above this point, 1-in. staggered vertical openings are provided between each block.

Distribution is effected by 3 Simpson steel tipping troughs discharging on to cypress diversion boards.

Settling Tank.—To retain the relatively large quantity of solid matters, intermittently discharged from the filtering material, a settling tank is provided, with an average retention of 0.5 hr. The tank is 5 ft. long and contains 2 compartments each 2 ft. wide, with an effective depth of 2 ft. The tank serves as a pump well to pump the effluent to the irrigation field.

Design.—An appreciably greater filter area is provided than necessary, to allow for an increased intake. The flush intake is only about 13,600 lb. of fluid milk. Assuming a 1.5 per cent loss, the milk solids lost per day are $13,600 \times 0.015 \times 0.125 = 25.7$ lb. On this basis, the required filter volume is $25.7 \times 80 = 2,056$ cu. ft. The actual volume of filtering material is 3,485 cu. ft. or at the rate of 135.6 cu. ft. per pound of milk solids. It is evident that the installation can satisfactorily handle the wastes from a much greater intake.

The cost of the plant was approximately $3,000.00.

Efficiency.—The plant began operations in the fall of 1928 and is giving excellent results. During the past summer the effluent has been clear, with a stated average 5-day BOD of about 20 p.p.m. The BOD of the raw wastes averages about 1,000 p.p.m.

Complete Treatment by Sand Filters.—Tests made at Grove City, Penn., by the United States Public Health Service (12) in 1916-1917, show definitely that milk waste under intelligent operation, can be satisfactorily treated on sand filters at a rate of at least 50,000 gal. daily as against the 25,000 gal. daily rate developed at Lawrence and standard for many years.

An opportunity to utilize sand filters arose in 1930 at a relatively small cooperative creamery in eastern Ohio. The flow of the receiving stream during the recent drought has been practically zero. This factory has been using a septic tank, the effluent of which gives rise to objectionable odors.

In the flush, cream receipts are about 6,000 lb. per day. Buttermilk and first churn rinsings are pumped to a buttermilk storage tank and are systematically hauled away by contract. Factory operations are such that the wastes are not contaminated by buttermilk curd.

In the design of the sand filters, it was assumed that the butter fat loss, exclusive of that in the buttermilk, does not exceed 0.5 per cent. Computed to 35 per cent butter fat cream, this is equivalent to a daily loss of 85.7 lb. on a flush cream intake of 6,000 lb. or at 6 per cent solids not fat, to 5.14 lb. milk solids. On the basis of treatment on trickling filters, at the provisional rate of 80 cu. ft. of filtering material per pound of milk solids not fat per day, the required volume of trickling filters is 411.2 cu. ft., at 8-ft. depth, equivalent to 51.4 sq. ft. Assuming operation at 1.0 million gallons daily, the corresponding area of sand filters at 35,000 gallons daily is 1,470 sq. ft.

It was possible at this factory to provide on company property, a sand area of about 1,806 sq. ft. On this basis, the rate of treatment is about 32,000 gallons daily, but computed from the actual volume of wastes, estimated at about 1,500 gal. per day of a 5-day week, the actual rate of treatment is about 35,300 gal. per day.

It is believed that the weight of milk solids not fat is a much more reliable index of the required area of either sand or trickling filters, than any volume-area ratio since, within the BOD limits already mentioned, it is the pounds of oxygen that the treatment plant or the receiving stream must supply, that really governs the size of any plant intended for substantially complete treatment.

This plant, which will go into operation next spring comprises a small dosing tank, operated by a standard sewage siphon and providing for flooding each of the 4 sand filter units to a depth of about 1.5 in.

The estimated construction cost of this small plant is about $1,500.

Conclusion.—Substantial progress has been made during the past few years in the art of milk waste treatment.

Where but partial treatment will suffice, these problems may be solved by the use of chemicals, of which sulphate of alumina is perhaps the most convenient. The sludge problem does not present unsurmountable difficulties.

Where complete treatment is required, for relatively small intakes, sand filters are available; for the larger intakes, trickling filters, with provisions for the sedimentation of the effluent, with the direct application of the fresh wastes in each case.

Septic tanks have no place in the program of modern milk waste treatment where approximately stable effluents are demanded.

Experience has demonstrated the necessity for securing complete information regarding intakes, factory processes and by-product disposition, before attempting to apply to any given problem the principles which underlie partial or complete milk waste treatment.

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City Engineers Show Economy of Building Now

Immediate construction of needed public improvements may be done now and in the near future to decided advantage because of low material and construction prices and plentiful and efficient labor, according to a statement issued by John W. Reid, consulting engineer of Detroit, president of the American Society of Municipal Engineers.

Mr. Reid points out that since most of the money spent for public improvements goes to labor that accelerated construction would furnish employment for large numbers of workmen and would tend to restore public confidence.

President Reid urges each member of the society to lend every reasonable encouragement and aid possible in the acceleration of needed public improvements of all kinds.

Construction of sewers, water systems, pavements, county and state highways, grade crossing eliminations, schools and other public buildings are suggested by Mr. Reid as the major improvements whose development at this time would contribute largely to relieving the present economic situation. Practically all municipal and state governmental agencies are now thoroughly well organized and manned to execute such improvements with practical dispatch, once the improvements are authorized and provision has been made for financing them.

The many thousands of men who would be directly employed by speeding up construction would not be the sole beneficiaries. The increased amount of materials that would be used in these projects would make necessary the employment of many other thousands. Workers must have equipment as well as materials with which to build, they require additional food and clothing and there must be men employed at the source of supply for these needs. Thus, a material increase of employment in one field brings about an increase in other lines of employment.

"There is little doubt," states President Reid, "that all citizens and taxpayers would approve programs contemplating only necessary improvements, since most communities have been striving for some time to catch up with requirements in the class of improvements named."

Municipalities that have allowed present business distress to interfere with the progress of their improvements can now take advantage of three important factors. Low prices of materials have given today's dollar greater buying power. There is a plentiful supply of efficient and experienced labor and construction prices are down. Taking advantage of these factors will accomplish a twofold purpose. Cities have an opportunity to economically bring their improvements up to date and at the same time furnish much needed employment to many thousands.

Plankton in Relation to the Natural Purification of Polluted Streams

Organic matter, such as sewage, provides food for certain kinds of organisms that are not present in unpolluted water. Finding these organisms, we know that the water is polluted, and that these particular organisms will disappear when their food supply is exhausted.

In order to learn more about the amount and kind of work done by these organisms in nature's purification of such a polluted stream, a study[1] was made of the much-discussed Illinois River, heavily polluted by the sewage and stockyards waste from the city of Chicago, and well suited to a study of this phase of microscopic life. Approximately 1,000 weekly samples, collected at every season, and including all sections of the river (which is nearly 300 miles long), were analyzed and studied. Particular information was sought relative to the abundance of such organisms as thrive in sewage-polluted water, and their gradual replacement downstream by organisms known to require water of a better grade. The gradual purification of the stream was thus expressed in terms of the prevalent kinds of microscopic organisms, both plants and animals, and collectively known as plankton.

The relative abundance of microscopic green plants was a matter of interest, inasmuch as these plants help to purify the water by the oxygen they give off, similar to the action of the common "fish moss" in goldfish bowls.

Very briefly summarized, the results of this study indicate the following changes as the water progresses:

1. The swift upper portion of the river, heavily polluted but thoroughly mixed, is well seeded at the start with microscopic organisms from the tributary Des Plaines River and from Lake Michigan.

2. Gradually decreasing velocity distributes the suspended matter over a very large total area of bottom downstream, facilitating biological action.

3. The grayish water becomes clear, and loses its odor of sewage 70 to 80 miles downstream from the Chicago Drainage Canal outlet.

4. Correlated changes in the plankton content are: (*a*) decrease of pollutional organisms formerly predominant; (*b*) increase of organisms of the cleaner-water kinds, these becoming predominant, and maintaining this status thereafter; (*c*) increase in relative abundance of microscopic green plants.

5. In all sections of the river, and at all seasons, the microscopic green plants were decidedly more abundant, volume for volume, then were the microscopic animals.

6. Malodorous bottom sediments from the polluted upper Illinois contained very large numbers of "sludge worms," and no gill-bearing insect larvæ, whereas sediments from the lower portions of this stream were free of odor, contained very few worms, and showed a variety of gill-breathing insect larvæ.

A suitable background for the above study is furnished by 11 abstracts of similar studies made by various investigators on other streams and on the Illinois River. The large amount of data relative to the Illinois River is summarized in 54 tables and 18 graphs. There are also a number of photographs showing field conditions, and some photomicrographs of the more important plankton organisms.

[1] A study of the pollution and natural purification of the Illinois River. II. The plankton and related organisms. By W. C. Purdy. Public Health Bulletin No. 198

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Forty Weather Cycles and Their Causes

About four years ago the editor began a research having for its object the determination of the number of weather cycles and their causes. This investigation is nearly finished. It has been found that each of the six largest planets from Mercury to Jupiter is responsible for four weather cycles, giving 24 cycles, and that each of the remaining large planets causes three weather cycles and presumably a fourth one that is so long that data have not yet been secured by which to confirm its existence.

The four rain cycles (the word rain will be used instead of precipitation) caused by a planet are perfectly commensurable or harmonic. They may be designated thus:

1. Primary cycle.
2. Secondary cycle.
3. Subcycle.
4. Supercycle.

The primary cycle is somewhat shorter than the orbital period of the planet. The secondary cycle is exactly the length of the orbital period. The subcycle is 1/6, 1/12 or 1/8th the length of the primary cycle. The supercycle peak occurs when the peaks of the primary and the secondary cycles coincide. For example the four cycles caused by Jupiter are:

1. Primary cycle, 11.203 years.
2. Second cycle, 11.862 years.
3. Subcycle, 1.4004 years.
4. Supercycle, 201.654 years.

The rain peaks of the secondary cycle of Jupiter, as well as of the other planets, are small.

Of the subcycles of Jupiter the most prominent rainfall peak is that midway between the peaks of the primary cycle, thus producing a rain cycle of 5.602 years. The 11.203 year weather cycle corresponds with a sunspot cycle of the same length—the one responsible for the most frequent of the great sunspot peaks. But since the rainfall peaks that occur (in certain regions) 5.6 years apart, are equally great, it follows that sunspots are not important factors in causing rain, for midway between the 11.2 year sunspot peaks is a sunspot valley.

The sunspots are cyclonic and anticyclonic storms caused by the planets; but, due to some peculiarity of the sun, their cycle peaks are often, as above indicated, twice as far apart as corresponding storm peaks on the earth.

For Jupiter:

$$17 \times 11.862 = 201.654$$
$$18 \times 11.203 = 201.654$$

or 17 of Jupiter's orbital periods equal 18 of its primary sunspot and rain cycles. In the case of every planet but Mercury, the two factors corresponding to the 17 and 18 for Jupiter differ by one. In the case of Mercury these factors are 20 and 25.

The following formula gives the approximate length (t) of each primary cycle in terms of the planet's orbital period (T):

$$t = T - 0.13\sqrt[3]{T^2}$$

In only one case out of 9 does this formula err by more than 3 per cent, that one case being Mars, for which the error is nearly 10 per cent.

The secondary cycle is caused by the lower magnetic field of the planet, corresponding to the earth's well known field. The primary cycle is presumably caused by an upper magnetic field due to an electron shell surrounding the planet, similar to the well known "Heaviside layer." By assuming that the poles of the upper field revolve clockwise very slowly about the poles of the lower field, it is evident that the maximum solar or terrestrial effect due to the upper field of a planet will occur at more frequent intervals than the orbital period of that planet; e. g., 11.203 yrs. for Jupiter's upper field.

Two of the most surprising recent developments of this research have been the discovery that the small planet Ceres (480 miles in diameter) and the most distant visible planet, Pluto, cause weather and sunspot cycles whose peaks are very pronounced. Scarcely less surprising was the discovery of a rain cycle (using Alaskan data) of the same length as the moon's siderial period of revolution, 27.322 days, and a subcycle that is ¼ thereof. The sun also causes a rain cycle of 29.55 days and a subcycle that is 1/6 thereof, due presumably to its period of axial rotation and probably to the existence of 6 permanent whirls, 60 degs. apart in longitude that are electromagnets by virtue of the electrons that are in these whirls.

Rainfall differs greatly in different parts of the earth, not so much because of differences in latitude as because of differences in position relative to the "permanent" cyclonic and anticyclonic whirl centers. Judging by topographical arcs, there were at least 12 great whirls in the earth's molten matter. There are known to be 3 "permanent" cyclones in our air and 6 permanent anticyclones. Each of these must be a huge but weak magnet. Since, according to the editor's theory magnetic tides in the atmosphere, caused by the planets and by the sun, determine the activity of these permanent atmospheric whirls, it follows that the weather often differs considerably in localities a few hundred miles apart. The differences may be very great during the same cycle peak.

Although the complexity of the rainfall problem is evidently great, it is not discouraging, for most of the 40 rain cycles have relatively small peaks. The major swings in the rainfall curve are due to 4 visible and one invisible planet, namely Jupiter, Uranus, Neptune, Pluto and Apollo, the last being an assumed planet whose

primary weather cycle is 316 yrs. with a subcycle 1/6 thereof, or 52.7 yrs. (Bradley recently discovered a stratification cycle of about this length.)

Pluto's primary cycle is 252 yrs. and its subcycle is 1/8 thereof or 31.5 yrs. which is the Bruckner weather cycle. The next subcycle peak of Pluto will be in 1942, and that of Apollo in 1936. Jupiter's next primary cycle peak will be near the end of 1939. Uranus has a primary cycle of 81.116 yrs. and a subcycle of 1/8 thereof, or 10.14 yrs. Its next subcycle peak will be about the middle of 1940. Since these 4 important cycle and subcycle peaks cluster around the end of 1939, it follows that we may look for increasing weather disturbances that will reach their maximum about 1939 or 1940. The cycle conditions then will resemble those of about the year 1883. The 80's were marked by very great rainfall in many regions and by unusually severe crustal disturbances, the worst of which was the explosive eruption of Krakatoa.

The editor has found no method of cycle investigation to be the equal of the cyclogram method of Balfour Stewart which is outlined in Clayton's "World Weather," p. 376. It is the acme of simplicity, and, with the aid of an adding machine, results can be quickly secured. Apparent cycles should be tested by probability formulas, in order to remove any doubt as to their reality.

The tree-ring measurements of Prof. Douglass, covering annual sequoia growth for 3,150 years have been found to be invaluable in establishing long cycles by the cyclogram method. Those trees dropped 2 rings about 1580 A. D., so the Douglass dating prior thereto must be corrected accordingly.

"Science Is Always Wrong!"

George Bernard Shaw's recent tribute to Einstein was heard by many of us over the radio. Some who are scientifically trained, were surprised to hear him say that Einstein had overthrown the Newtonian system. They were not surprised because of the novelty of the statement, but because of its absurdity—and Shaw is seldom absurd. In that connection he said: "Science is always wrong. Science never solves one problem without raising ten more."

A curious thing is this system of erroneous knowledge called science, when it serves to guide ships across the wastes of water and gives the navigator information by radio across the wastes of air. By what necromancy is Newton's erroneous system able to give true answers as to the dates of eclipses and the return of comets that have been lost in space for a life time? Strange indeed is this system that is "always wrong" yet so amazingly right.

We have protested before and we protest again against the metaphysical nonsense that many a sensible man like Shaw is uttering about science. Since when has it become logical to charge a man who lacks complete knowledge with being utterly ignorant? Newton, it is true, lacked complete knowledge about gravitation. He did not know that the mass of a body increases as its velocity increases. It remained for Einstein to find that out. Yet except at very high velocities this refinement of the Newtonian theory leads to no results that are measurably different from those derived by the Newtonian theory. This does not detract from Einstein's achievement, nor from Newton's.

Was the first gasoline motor-car that Selden drove through the streets of Rochester 45 years ago "all wrong" because of its imperfections? It was "right" enough to travel. And the patent that Selden received still covers the basic principles involved in every road vehicle propelled by an internal combustion engine. Precisely the same sort of "rightness" is to be found in every scientific theory that has led to new discoveries. The Keplerian law that planets travel in elliptical orbits is not precisely true. None the less it served to guide Newton to the cause of the approximate ellipticity, as Newton's law served in turn to guide Einstein.

As well say that my watch is "all wrong" because it does not give time in split seconds as to say that Newton's law of gravitation is "all wrong."

Einstein has already developed his own theory of relativity to a higher degree of accuracy than it had when he first announced it. He calls his original theory "the special theory of relativity" and he calls his new theory "the general theory of relativity." It will not be surprising if he lives to revise it still more.

Scientific theories are like mechanical inventions in that they are never perfect, and evolve more or less slowly toward a closer accord with the facts of nature. Nature, however, is a congeries of interacting forces that are so complex and so variable in intensity and direction of assault that man never will be able to fashion any physical theory that it is quantitatively perfect. The researcher begins by assuming a simplicity that does not exist in nature; but if his theory is fundamentally sound, he is able thereby to gain a better understanding of some of the interacting forces and their effects. Sooner or later it is discovered that the simple theory does not fit all the facts with sufficient accuracy. Then some other force or force variation is introduced, thus bringing the theory into still closer accord with facts under a wider range of conditions. Scientists then may think that the theory has been fully perfected, and turn to exploration of other realms. Hardly has that occurred before someone else begins anew where they left off—and, lo, another Einstein "perfects" another Newtonian formula!

Let us be quits of this nonsense that "Science is always wrong."

In defending the Newtonian theory we are not belittling the Einstein theory. While Einstein's "relativity" has had no effect on the practice of celestial mechanics as yet, and none on engineering practice, it has opened up new realms whose exploration is likely to yield practical results of great value. Take, for example, his conception that matter and energy are but different names for the same thing, and his formula that shows the amount of energy in a given mass of matter. It is almost incredible that a pen-knife contains enough energy to drive a great steamship across the Atlantic. Being true, it has excited the ambition of many a researcher to find a way of releasing the energy that all mass contains, or rather is. Tomorrow's newspapers may tell us that this has been accomplished. When that news comes, it will bear with it news of the utmost practical importance, for it will forecast the not distant end of coal, oil and water power as the main source of the energy that drives most of the power machines that men have made.

H. P. Gillette

DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Worthington Pump Holds District Managers Meeting

The second annual meeting of the district sales managers and sales division heads of the Worthington Pump and Machinery Company was held at the general sales offices, Harrison, New Jersey, February 9 to 11th, inclusive.

Following up the object of the first meeting held in December, 1929, to promote teamwork and mutual understanding, this second meeting took up questions of office routine in the interests of efficient management and effective standardization of business procedure.

Several changes in the Cincinnati staff of the company have been announced by H. A. Feldbush, works manager. Michael Riesner, who became an apprentice machinist at the Cincinnati works in 1892, and has advanced through various steps to chief engineer has been relieved of many of his former duties to concentrate more fully on the design and development of new and improved products.

A. V. Saharoff is announced as works' engineer and will take over some of the work formerly under the direction of Mr. Riesner. Mr. Saharoff has been connected with the Cincinnati works of the company for the past twelve years, for the past year and a half as general superintendent.

R. L. Rickwood will succeed Mr. Saharoff as general superintendent, and J. C. Russell has been made production manager. Mr. Russell was first connected with the drafting department and was later transferred to the production department and for the past year and a half has served as assistant general superintendent.

The St. Louis district sales office of the Worthington Company, has recently moved into new quarters, and is now located in the Ambassador Building, 411 North 7th Street, St. Louis.

Barber-Greene Holds Sales Conference

Preceding the annual Road Show at St. Louis, fifty-five representatives of the Barber-Greene Company, coming from all parts of the United States and Canada, assembled at the Aurora plant for a two days' sales conference.

The meeting took the form of an instruction course with class room lectures and laboratory work. The lectures were illustrated by educational movies, and the laboratory work included a review of all the machines produced by the company including those to be introduced in 1931.

H. H. Barber and W. B. Greene, president and vice-president of the company, addressed the visitors, and various company officials outlined the policies and methods of the home plant. Other speakers included J. W. O'Keefe, secretary of the Chicago Association of Credit Men; H. J. Fauber, president of the Central West Engineers, Inc., of St. Louis, a company that has laid extensive pipe lines in the middle west; and Mike Andrews, foreman second in charge of the concreting by conveyor of the Marshall Field Merchandise Mart, and more recently in charge of the same operations on the three million dollar American Can Company building in Chicago.

A moving picture covering methods of constructing black top road secured from the United States Government was shown and a demonstration was given of the black top road builder, the newly designed machine for building finished bituminous road in one operation. This machine was later shipped to St. Louis for exhibition at the Road Show, which many of the men attended after leaving Aurora.

Caterpillar Announces Advisory Staff

Charles A. Spears, recently appointed general supervisor of construction and governmental sales for the Caterpillar Tractor Company has announced the staff of engineers to work on these problems. It is said that rarely has a manufacturer made available to the public such an advisory staff of engineering brains.

The staff is introduced to the readers in the accompanying picture in left to right order as follows:

R. H. Gardner, who has served as district representative of the southeastern area for the past two years. Mr. Gardner is well known in Atlanta and is said to be a close friend of that world citizen "Bobby" Jones. Mr. Gardner is a graduate of Washington & Lee University.

Walter Harn, former contractor and identified with such construction achievements as the Cleveland City Hall, and a representative for Caterpillar in Arizona and Southern California. Mr. Harn will be located on the coast and will cover territory west of the Rockies for Mr. Spears.

Mr. Spears, himself, is in the center of the group. He is former head of Spears-Wells, manufacturers of road machinery, and has done construction engineering work in the west for the past 15 years.

Ralph J. Morgan, who has served in southern territory for his organization and knows highway and levee construction, engineers and government officials intimately will contribute this experience. Mr. Morgan is a former United States Department of Agriculture specialist on marketing and cooperative organization.

Frank A. Nikirk has had some 30 years' experience in road and street building and maintenance, sanitary engineering, city planning and management, railroad building, and has served Caterpillar on the west coast for the past four years.

Caterpillar Engineering Advisory Staff

Horace Wesley Clark

The death of Horace Wesley Clark, January 19th, at his home in Mattoon, Illinois, removed from the water works branch of the engineering field one of its best known figures. Mr. Clark, the inventor of some fifty types of water works equipment, of which the Clark meter box is probably the most important, was the organizer and head of the H. W. Clark Company from the time of its foundation until his death.

Horace Wesley Clark was born in Mattoon May 28, 1871, the third son of the late Judge and Mrs. Horace S. Clark, pioneer residents of that Illinois town, where he spent his entire life.

Horace Wesley Clark

Mr. Clark was educated at Lee's Academy in Loxa, Coles County, and studied law in his father's office. It was expected that he would carry on in the legal profession, for his father was one of eight brothers, six of whom were lawyers. The chance purchase of the local water works by his father in the year 1891 completely changed the son's career and Mattoon lost a lawyer and the world gained an inventor and manufacturer. Horace W. Clark was made superintendent of the water works, then a small plant, and later became owner and assumed full management, installing one of the first electrified water plants in the country. This plant was purchased from him in 1912 by the Central Illinois Public Service Company.

As early as 1893 Mr. Clark conceived the idea of a frost proof meter box to protect the water meter at the curb from the weather and tampering. This idea led to the invention of the Clark meter box which was patented in 1902. For ten years the manufacture of this product was carried on by machinist and founder. In 1912 the H. W. Clark Company was incorporated to manufacture the Clark meter box, and the company took occupancy of their new factory in 1913.

Mr. Clark was one of the founders of the Illinois Water Works Association, and held memberships in the New England Water Works Association, the Southwest Water Works Association, the American Society of Engineers, and when in 1895 he joined the American Water Works Association at the age of 24 years, he was the youngest member. At the time he joined this association it had but 300 members, the membership is now close to 3,000. Then there were less than 2,000 water works plants in the country and today there are approximately 10,000.

Aside from his professional association memberships, Mr. Clark was a charter member of the Mattoon Rotary Club, a charter member of the Mattoon Country Club and a member of the Association of Commerce. He belonged to the Knights of Pythias and to the Modern Woodmen. He was a member of the Methodist Episcopal Church, being president of the board of trustees at the time of his death.

Mr. Clark had an interesting family background. His father, one of a large family of brothers and sisters, was a civil war veteran, lawyer and politician and was at one time candidate for governor of the state of Illinois, and served as a state senator and state commander of the G. A. R. Mr. Clark's sister was Czarina Clark Tillotson, a well known vocalist, and his surviving brother is Russell S. Clark, a Chicago attorney.

In 1891, Mr. Clark married Miss Inez K. Moore, daughter of Mr. and Mrs. Calvin Moore, pioneer residents of Mattoon. There are three sons, Kenneth Wesley Clark, Donald Moore Clark and Horace Pomeroy Clark, and three grandchildren. Mr. Donald Clark will succeed his father as the head of the H. W. Clark Company.

▾

Cummings Made Cleveland Manager for Sullivan

The Sullivan Machinery Company of Chicago announces the appointment of Chester G. Cummings as manager of the company's branch office at Cleveland, Ohio, to succeed R. T. Stone, resigned.

Mr. Cummings has for a number of years been associated with the New York office of the Sullivan company with headquarters at Syracuse. His Cleveland office is located in the Rockefeller building.

▾

C. B. Murphy Promoted

Fairbanks, Morse & Company announces the appointment of C. B. Murphy as manager of the stationary Diesel engine sales with headquarters in Chicago.

C. B. Murphy, Manager of Diesel Engine Sales for Fairbanks, Morse & Co.

Mr. Murphy's experience, after he finished his schooling at Purdue University in 1911, has been almost entirely with the Fairbanks-Morse organization. For the first two years of his business career he was connected with the Engineering Department of the Illinois Central Railroad. In 1913 he became a general line salesman in the Florida west coast territory and since the introduction of the F-M Diesel in 1915 he has devoted his time to that one product exclusively with two years' time out in '18 and '19 for service in the Naval Aviation Ground School at Minneapolis. In 1924 he was transferred to the executive offices as assistant to the manager of the Diesel Engine Division and in 1929 was transferred to Washington as special representative of that Division.

▾

W. A. Kohlhoff Made Sales Engineer of Hydrauger Corporation, Ltd.

W. A. Kohlhoff has been appointed Sales Engineer of the Hydrauger Corporation, Ltd., according to announcement from the headquarters of the corporation in San Francisco. He has been in the gas engineering department of the Pacific Gas & Electric Company for the past ten years, having been with the Coast Valleys Division of that company before taking up his new work. Mr. Kohlhoff has also served in the North Bay and the San Francisco divisions of the Pacific Gas & Electric Company. His engineering training was received at the University of California.

As Sales Engineer of Hydrauger Corporation, Ltd., Mr. Kohlhoff soon will make a business tour of the United States to establish distributing agents for the Hydrauger Company on the Atlantic Coast, in the South and the Middle West.

The Hydrauger is a hydraulic auger for boring horizontally under streets, highways, sidewalks and gardens, for the laying of pipes, condulets and drains. The machine has been placed on the national market and has won wide attention because of the savings involved in its use, which avoids pavement-cutting almost entirely.

▾

Goulds Official Co-Recipient of Melville Award

The Melville Medal of the American Society of Mechanical Engineers, established in 1914 by the bequest of Rear-Admiral George W. Melville, honorary member and past president of the Society, for an original paper or thesis of exceptional merit, was presented jointly to Professor Herman Diederichs of Ithaca, New York and William D. Pomeroy, Seneca Falls, New York, as co-authors of the paper on "The Occurrence and Elimination of Surges or Oscillating Pressures in Discharge Lines from Reciprocating Pumps."

Professor Diederichs is Professor of Experimental Engineering and Director of the Sibley School of Mechanical Engineering, Cornell University.

Mr. Pomeroy, who is an authority on oil pipe lines and pipe line pumps, is Vice-President and General Manager of Goulds Pumps, Incorporated, Seneca Falls, New York.